14 DAYS
BOOK

THE ELECTRICAL INDUSTRY

THE "ENGINEERING SPIDER"

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FRONTISPIECE

THE ELECTRICAL INDUSTRY

LIGHTING, TRACTION, AND POWER

BY

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SIR ROBERT GIFFEN, K.C.B., LL.D.,

THIS VOLUME IS

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THE ELECTRICAL INDUSTRY

CHAPTER I

THE BIRTH OF THE ELECTRICAL INDUSTRY

IN the *Times* reprint of the 'Encyclopædia Britannica' the following sentence occurs under the heading 'Electricity': 'It has been proposed of late to employ electro-magnetic machines in lighting streets and workshops, and the experiment has been tried with some success.' When he wrote that sentence, the 'Encyclopædia Britannica' authority had clearly no idea that the 'experiment' of lighting streets and workshops by 'electro-magnetic machines' was the beginning of a great industry. Nothing could show better the very recent birth of commercial electricity than that sentence from a work which, as a whole, was sufficiently up to date to command a very

large sale in quite recent years. Before 1879 the electrical industry did not exist.

On the other hand, the industry has made tremendous progress in the twenty odd years since it was born—progress much more rapid than that made, say, by the steam-engine a century ago. There are reasons for the rapidity of the advance, and a glance at the history of the science will show how it was that electricity suddenly appeared in the commercial world after having passed centuries in the grub-stage in the laboratories of philosophers.

Our very remote ancestors were acquainted with only two forms of electricity: that supplied as a natural weapon of defence and offence by the 'torpedo,' and that generated by the rubbing of bodies such as amber, from the Greek name of which the Englishman, Gilbert, gave electricity its name. Neither of these forms is ever likely to be of use industrially, as the supply is small in quantity and difficult to obtain. The first step towards industrial possibilities was made in 1793 by Volta, who, following Galvani, invented the famous 'pile' and 'crown of cups,' which figure in every text-book on electricity. Both these devices produced a continuous flow of electricity along a wire, or, in other words, an electric current. After their discovery further progress

was made by leaps and bounds. Early in the nineteenth century Oersted, a Dane, proved by a simple yet epoch-making experiment that philosophers were right in suspecting some connection between electricity and magnetism. He held a wire carrying an electric current over a compass needle, and the needle was deflected from its usual north and south position by the action of the current. This seems a trivial experiment, but it was the beginning of the science of electro-magnetism, which gave us the electro-magnetic machines referred to in the sentence quoted from the 'Encyclopædia Britannica.' These in turn gave us the electric generators which have made possible commercial electric lighting, electric traction, and electric power-supply.

Oersted was a contemporary of Humphry Davy, who worked in the laboratory of the Royal Institution, and laid the foundation of three branches of the electrical industry. By his discovery of the power of the electric current to decompose potash into its elements and to fuse platinum and other metals, he originated the twin industries of electro-chemistry and electro-metallurgy. It was he, too, who made the first 'arc-light,' the forerunner of the brilliant electric street-lamps of to-day.

Great as were Davy's achievements, they are

apt to shrink when put alongside those of his successor at the Royal Institution, Michael Faraday. From the point of view of industrial developments, the climax of Faraday's work was the invention of the first dynamo. Faraday himself had probably no notion of the tremendous changes which would flow from this discovery; to him the immediate scientific interest of the subject was all-sufficing. He certainly did not know that in constructing a machine which would continuously convert mechanical energy into electrical energy he was setting in train a series of inventions which would ultimately revolutionize our methods of transport and lighting, and bring about a new era in power-using industries.

Faraday's dynamo was, of course, a mere toy. It was no more a dynamo, in the present-day sense, than Watt's bubbling kettle was a steam-engine. Its importance lay, as we have just hinted, in the fact that it showed a new way of producing currents of electricity. Before the invention of the dynamo electric currents were produced by means of batteries similar in principle to those still used for electric bells, telephones, and so on. The pressures and currents supplied by one or two such batteries are very small, and experimenters in Davy's and Faraday's time were obliged to use a large number of batteries if they wanted currents

of sufficient quantity and pressure to produce, for instance, an arc-light.

Faraday's discovery made it possible to substitute mechanical for chemical activity in the production of electrical energy. He made it possible to generate an electric current simply by forcibly turning a handle. The instrument he used was a copper disc, which he caused to revolve near a horseshoe magnet. When one end of a wire is connected with the centre of the disc and the other end kept in touch with the moving edge, a current of electricity flows along the wire. By this contrivance the mechanical energy used in turning the disc is transformed into electrical energy.

To the lay mind there is something mysterious in this transformation. It is difficult to see why the mere moving of a piece of copper near a magnet should produce an electric current in the copper. No complete explanation can be given until we know what electricity is, to begin with, but the apparent mystery can be explained as fully as any other of Nature's wonders. Every magnet has a sphere of influence round it, diminishing in strength the further one gets from the magnet itself. Close to the magnet, pieces of iron are strongly attracted; as we go further away the attraction diminishes. One of the peculiar quali-

ties of this sphere of influence is that a closed metallic circuit, like a copper ring or a piece of wire bent into a complete circle, cannot be rotated in it without the exertion of force to overcome the effect of the magnet's influence. There is no resistance visible, but it is nevertheless there, and has to be overcome in the same way as the invisible force of gravity has to be overcome in raising a weight from the ground. If the copper ring be thus forcibly moved, an electric current is generated in it, growing in strength with the intensity of the magnet's sphere of influence and with the rate at which the ring is moved.

That is the principle of the dynamo and the foundation of the electrical industry. Faraday's dynamo, however, gave only a very small strength of current. It was worked by hand, and could, of course, give no more energy in the form of electricity than was put into it in the form of mechanical energy by the hand of the operator. A more powerful machine was made by using coils of wire instead of the copper disc; these coils were spun near the poles of a magnet, and in some forms of machine the coils were fixed and the magnets were made to revolve. This type of electric generator survives in the magneto-electric machines, sometimes called 'medical batteries,' sold for the purpose of producing small electric

currents suitable for use in certain medical cases, and also as a dubious form of entertainment at country fairs.

By multiplying the number of coils and magnets, and using steam power instead of hand, currents of greater strength were produced. Machines on this principle were made at about this period for producing electric light for lighthouses, and the invention of the 'Siemens armature' in 1856 was a great step towards efficiency in the larger sizes of electro-magnetic machines. But all the progress that was made could not wipe out the great drawback of the machine. It was practically impossible to get steel magnets of sufficient strength to produce really powerful currents. The 'spheres of influence' were weak, and the currents they induced were likewise weak. So inventors set to work to remove this drawback.

On February 14, 1867, two papers were presented to the Royal Society, one by Charles Wheatstone and the other by Carl Wilhelm Siemens. By a curious coincidence, both these papers made practically the same suggestion for a revolutionary change in the making of dynamos. They proposed that permanent magnets should be abandoned. In place of that means of producing the necessary magnetic sphere of influence, Siemens and Wheatstone proposed that use

should be made of the 'residual magnetism' of the soft iron of an electro-magnet. Although soft iron rapidly loses all obvious traces of magnetism after it has, say, been magnetized momentarily by the passage of an electric current near it, a certain amount of magnetism lingers in it. If a piece of soft iron is put in place of the permanent steel magnet in a magneto-electric machine, a current will be generated in the revolving coils, but it will be a very feeble one. Suppose, however, that, as Wheatstone and Siemens suggested, we connect the revolving coils with a coil of insulated wire wound round the mass of soft iron. A portion of the induced current—feeble as it is—will pass along the connecting wires and through the coil, magnetizing the soft iron. This access of magnetism strengthens the sphere of influence of the soft iron, thus inducing stronger currents in the revolving coils. A part of this stronger current passes round the soft iron, magnetizing it more powerfully, and consequently inducing still stronger currents in the revolving coils. And so the process goes on, until the magnetism of the soft iron core is raised step by step to the point of saturation, and the revolving coils are giving electric currents of very high strength, far higher than could ever have been obtained with steel magnets.

To Wheatstone and Siemens, therefore, we owe the commercial dynamo. Following their suggestion, it became possible to generate electric currents of practically unlimited strength. Since the invention of Faraday's dynamo the world had been waiting for this idea, and while it waited it was adding greatly to its knowledge of the science of electricity. It has been well said that at the period of Siemens and Wheatstone's announcement the science of electricity was well advanced, but the art hardly at all; in other words, electricity was well known in the laboratory, but was only a nodding acquaintance in the outer world. The value of the laboratory knowledge was shown in the rapid progress which was made in dynamo construction. Once the leading idea was obtained, men applied their intimate knowledge of the principles of electricity to the work of developing it, and before the year 1880 they were making dynamos which for efficiency could not be much bettered by those made nowadays. Thus it was that, while chance kept the birth of the commercial dynamo back for many years after Faraday's discoveries, the steady progress of electrical science had gone so far that, when the commercial dynamo did appear, it grew to maturity in a very short time.

Of course, the dynamo, as a dynamo, is not

a commercial article like a food or a musical instrument. It is only a means to an end, the end being the useful application of the electrical energy which the dynamo produces. That energy may be applied to produce light, or heat, or chemical changes, or to reproduce in some useful form the mechanical motion which originally produced it by working the dynamo. The commercial success of the dynamo therefore depended on the development of ways and means of transforming electricity into light and heat and using it for motive purposes, such as driving machines and vehicles. As it turned out, the dynamo was ahead of the rest of the electrical company; it had to mark-time a little while the others were being improved up to the commercial standard. The first to reach that stage was the electric arc-light; and, indeed, it might almost claim to have been there before the dynamo itself. Davy's original arc-light had been improved upon by using hard carbons from gas-retorts instead of soft wood charcoal, and by the use of regulating devices which 'fed' the carbons as they were consumed away in the blaze of the electric light. A fair amount of success had been gained by the time that the dynamo became a commercial article; in fact, the electrical industry was begun by the dynamo and the arc-lamp in partnership.

CHAPTER II

THE EARLY DAYS OF ELECTRIC LIGHTING

THE early days of electric lighting are still famous—or infamous—for two exciting incidents: one the slump in the price of gas shares, and the other the mad speculation in the shares of electric-lighting companies.

The gas slump was a very serious affair while it lasted, though in the light of after events one is inclined to look upon it as an unnecessary compliment to a rival. When the shareholders in the gas companies began to get nervous about electric light, the newcomer had really done very little to justify the nervousness. Gas had held the field for a couple of generations and more as the best and cheapest means of lighting streets, halls, and houses. It had produced a huge and profitable industry; it had, in fact, become a first-class 'vested interest,' with miles of mains and millions of burners. Yet at the first appearance of the

electric arc-light in a commercial form the gas world took fright, like the typical old maid at a mouse. Domestic electric lighting was still a thing unknown; methods of distributing electricity from a central station over a large district were still undeveloped; and the electrical installation then in use consisted of a small steam-engine and a dynamo, producing enough light for half a dozen arc-lights. The state of electrical development at this time may be gathered from a remark made in 1879 by Mr. (now Sir William) Preece before a Parliamentary Committee. 'The electric light,' he said, 'is only economical when one machine is used to produce a single light.' Lighthouses and large open spaces were considered to be the most suitable places for illumination by electricity, while a good trade was done by dynamo-makers in selling 'travelling sets' to circuses. The engines, dynamos, lamps, and wires were carried from town to town along with the Wild Man from Borneo and the other curiosities of the show.

It is only fair to the nervous gas shareholders to admit, however, that they were more afraid of what electric light threatened to do than of what it had done. So long as electric light was fit only for wide open spaces and travelling circuses, little was to be feared. But all the world knew that many electricians—and among them Thomas Alva

Edison—were busy trying to 'subdivide the electric light,' as the expression went in those days. This really meant that they were trying to invent an electric lamp which would give an economical light of the same power as an ordinary gas-burner —8 or 16 candle-power. It was one thing to light the Albert Hall, as Siemens did, with five arc-lamps of 6,000 candle-power each, and it was quite another to find an electric lamp suitable for domestic lighting. The arc-lamp was of no use for the purpose; it was nothing if not brilliant, with the concentrated brilliance of hundreds or thousands of candles.

The announcement of the first success in the attempt at 'subdivision' came at a rather dramatic moment and with a rather startling effect. At a meeting of the shareholders in the South Metropolitan Gas Company in 1878, the Chairman (then Mr. George Livesey) assured the proprietors that they had nothing to fear from electric lighting, since it had not been applied to domestic purposes. Almost while he was speaking Edison was cabling over from New York that he had succeeded in 'subdividing' the electric light. The announcement was made public on this side just as the shareholders were congratulating themselves that a threatened danger did not exist. The effect of the news was magical. From all over

the country holders of gas shares rushed to sell out, and, in spite of all efforts to resist the panic, the collapse was complete.

Many sensible people, whose sense of perspective was not dazzled with the brilliance of the arc-light, took advantage of the situation to purchase gas shares at a price far below their present value. The recovery to a normal level was aided by the fact that Edison's announcement was a trifle premature. He had certainly succeeded in inventing a 'subdivided' light, which took something like the form of the incandescent electric lamps which are now so common; but his lamp was a lamp of the laboratory and not of commerce. It was similar to the lamp of to-day, but he used a thin platinum wire instead of the prepared carbon filament now employed.

After a good deal of experiment, Edison tried a carbon filament, and eventually he succeeded (about the year 1880) in obtaining an electric 'glow' lamp which gave a bright light of good colour and suitable candle-power for domestic lighting. By a curious coincidence Mr. J. W. Swan had been working in England on very much the same lines, and almost simultaneously with Edison had taken out patents for an incandescent lamp with a prepared carbon filament.

Coincidences of this kind usually lead to patent

cases, from which some lawyers and few people of any other denomination derive much benefit. Both Edison and Swan had in 1882 founded companies, with a nominal capital of £1,000,000, to exploit their inventions in England; but the two companies sensibly agreed to amalgamate, instead of cutting each other's throat to make a lawyers' holiday. Accordingly, the Edison and Swan United Electric Light Company, Limited, was formed in October, 1883. As long as the incandescent lamp patents lasted, this company enjoyed a practical monopoly, because the carbon-filament lamp continued to hold the field against all other forms for domestic lighting by electricity. When the patents lapsed many other companies took up the manufacture of incandescent electric lamps, and the business now forms a very important branch of the electrical industry. The keenness of competition between foreign, English, and American makers has brought the monopoly price of 5s. per lamp down to 1s. or 1s. 6d., and has forced manufacturers to seek their profits mainly through economies in their methods of making the lamps.

If great things were expected of electric lighting when the arc-lamp was alone in the field, greater things were expected when the incandescent lamp made domestic as well as public lighting by elec-

tricity a practical thing. It is a little difficult for us nowadays to realize the extravagant notions which people had in the earliest eighties of the commercial possibilities of electric lighting. Accustomed as we are to electric-lighting companies earning dividends of 4 to 6 per cent. in the provinces, and round about 12 per cent. in the pick of Metropolitan districts, it is strange to reflect on the period of speculation which set in before even the first company for the general supply of electricity had got to work. This speculation is still referred to as the 'Brush boom,' owing to the part played in it by companies formed to exploit the dynamo and arc-lamp invented by Charles F. Brush, an American.

In 1880 the Anglo-American Brush Electric Light Corporation, Limited, was formed to acquire the Brush dynamo and arc-lamp patents in Great Britain for the sum of £200,000, half of which was to be paid in cash. Such a price would have been large enough if the Brush dynamo and arc-lamp had been the only things of their kind in existence—which, of course, they were not. But the extravagance of the price is forgotten in the thought of events that followed the operations of the company.

In 1882 the Brush boom began. The Anglo-American company became a prolific parent of

subsidiary companies in London and various provincial districts. To these subsidiary companies it accorded the right, in exchange for large amounts in cash and shares, to deal in Brush dynamos and arc-lamps. That is to say, it created agents all over Great Britain, and made the agents pay handsomely for the privilege before they earned a single penny.

One example will be enough to show the preposterous nature (it is easy to be wise after the event) of these arrangements. The Metropolitan Brush Electric Light and Power Company, Limited, was formed in 1882 with a nominal capital of £1,000,000; it agreed to pay Father Brush, as the parent company was called, the sum of £175,000 in cash for the right to sell Brush dynamos and the right to use the Lane-Fox incandescent lamp in the Metropolitan area. The Lane-Fox lamp, we may mention, was an incandescent lamp from which much was expected at the time, though the Edison - Swan pattern eclipsed it. When one considers that the sum of £175,000 was paid merely for the right to *sell* one kind of dynamo among many in a single district, and the right to *use* (not even the sole right) an incandescent lamp of indefinite value, one begins to think that in 1882 people were, as Mr. James Staats Forbes said of a more recent

time, 'a little mad on electricity.' How general the madness was may be understood from the fact that the first capital issue of the Metropolitan Brush company was subscribed for three times over. The successful flotation of the Brush babies enabled Father Brush to pay a dividend of 100 per cent., while his shares rose out of all knowledge and all financial sobriety.

Nemesis came swiftly. The Brush babies found themselves with expensive privileges, which were of no money value until a demand for electric light had been created. Even at the present day, when electric light has become the light of the cottage as well as of the palace, companies find that it requires push and ingenuity to persuade 10 per cent. of a population to give up old methods of lighting for the new. In 1882, however, electric light was called 'the light of luxury,' and it was found in few places outside railway-stations, clubs, and large private houses. The supply of electric light on the same general scale as the supply of gas light was only beginning in the most tentative fashion. Moreover, the Brush companies were not alone in the field; there were others equally anxious to sell good dynamos and good lamps.

When the actual conditions of commercial electric lighting came to be better understood, the

reaction from extravagant hopes set in. The final blow to these hopes was delivered by an Electric-Lighting Act passed in 1882. Here the electrical industry first made the acquaintance of the law—an acquaintance which led to a rather quarrelsome intimacy. The distribution of electricity from a central station to a large number of consumers involved the opening of streets to lay cables, and the opening of streets required Parliamentary powers. Several Bills to obtain such powers in different districts of London were brought before Parliament, and were referred to a Committee of the House of Commons. The deliberations of the Committee resulted in the passing of the Electric-Lighting Act of 1882, which empowered the Board of Trade to grant Provisional Orders authorizing companies and local authorities to give a public supply of electricity in local districts.

The local authorities were to possess their powers in perpetuity; the companies, on the other hand, were given only twenty-one years to live. At the end of that period the local authorities had power to purchase the company's undertaking at 'structural value,' which, being interpreted, is scrap-iron value, without any allowance for goodwill or compulsory purchase. Alternatively, the Board of Trade had power to grant licenses enabling companies to supply in a district

for a space of seven years, at the end of which the license might be renewed or not, as the Board of Trade thought fit. The object of the licenses was to enable experiments to be made under conditions which would allow the authorities to wipe the slate clean again if things were not going on to their satisfaction.

Such was the gist of the Act which put a stop to electric-lighting enterprise, much as one might turn off water at a tap. It was framed and passed, one must remember, at the full flush of extravagant ideas about the profitable nature of electric lighting. Even the Board of Trade, led by the reckless competition of various inventors, imagined that companies would be pleased to lay down experimental installations for a run of five years; so high were its ideas of the commercial prospects of electric lighting that the period of twenty-one years was considered ample to allow a company to reap its profit and redeem all the capital which would be lost under the terms of expropriation. There were not wanting warnings, from the late Sir F. Bramwell and many other experienced men, that the public supply of electric light with so short a period of tenure and so onerous a basis of expropriation would be found practically impossible. Sir Frederick humorously likened the situation to 'the devil in great wrath having but

a short time.' But the warnings were unheeded till experience proved them fully true.

One hundred and six Provisional Orders were applied for in 1883—the first year of working of the Act. Sixty-nine were granted, many of the London ones being obtained by the Brush Companies. Then came the tussle. Capital had to be obtained to work these Orders, but capital, having sowed its wild oats over electricity, was reformed and cautious. It examined the conditions of the business, and found them lamentably wanting. Mr. James Staats Forbes gave, in his evidence before a Parliamentary Committee in 1886, a picturesque account of his efforts to obtain capital for electric lighting—and their failure:

> 'Here is a Provisional Order; the Act contains certain principles, and they are worked out with great detail; there are innumerable pages of what you may do, what you may not do, what you shall be punished for not doing, etc., etc. What is the practical method of procedure? I go into the City, and I meet gentlemen who have the key of the position, the money—not outsiders, but men whose life has been spent in developing commercial enterprise. They say: "Well, now, what is this? Have you got something to sell?" "Yes." "What is it?" "This document." "This document! Ridiculous! Take it away.' What are the vital principles of it? We would not look at it without lawyers and brokers and every kind of business man. Nobody can tell what that is. What do you say is in it?" I say: "Amongst other things, here are pains

> and penalties, limitations of profit, limitations of price, compulsory purchase on such and such terms, and so on." "My good Mr. Forbes, with your experience of these things, how can you come with such a dish as this?"'

Most of the sixty-nine dishes met with a similar fate, since only a few of these early Provisional Orders are now in force. Next year (1884) only four applications for electric-lighting Provisional Orders were made and granted; none of them survived. In 1885 only one application was made, and it was refused. So sudden a collapse of activity was, of course, fatal to the speculative Brush babies. The price of their shares fell as fast as it had risen, and one by one they disappeared into the limbo of liquidation.

Although the paralyzing effect of the Electric Lighting Act of 1882 was almost immediate, several years passed before Parliament could be made to realize that the Act should be amended. During these years, and, indeed, up to the year 1888, when an amended Act was passed, electric-lighting progress in this country hardly existed. Private installations were, of course, fairly common, and a moderate amount of business was done in supplying dynamos and lamps to light public buildings, clubs, hotels, and other places, where people were prepared to pay for the cleanest,

healthiest, and best-toned light in the world. But only in a few cases had attempts been successfully made to establish the general house-to-house supply of electricity from a central station, after the model of gas-supply over a town from a central gasworks; in other words, an electric lighting business of the now familiar kind was then very rare.

Meanwhile, however, our cousins in America, and our more distant relations on the Continent, were not bound by an Act which gave their electric-lighting companies only twenty-one years of restricted life, ending in confiscation at scrap-iron value. They were free to do their work under ordinary commercial conditions, and, consequently, when a Select Committee of the House of Lords met in the year 1886 to consider the amendment of the Act of 1882, evidence was put before it that our rivals had made good use of their opportunities. Up to the year 1882 British electrical engineers had been, if anything, more active and advanced than their fellows abroad. Colonel Crompton, of the well-known firm of Crompton and Company, Limited, has related, for instance, that he was turning out commercial dynamos at the rate of one per day long before the Allgemeine Elektricitäts Gesellschaft and other great German electrical manufacturing com-

panies had been thought of. At any rate, the need of reform in the law was easily made clear to the Committee, and it reported in favour of an amended Act, which, after many delays, was passed in 1888. The great feature of the new Act was that it extended the period of tenure from twenty-one to forty-two years; the terms of expropriation were improved only to a slight extent, but the longer lease of life made electric lighting what it had not been since 1882—commercially *possible*.

Naturally enough, it took the industry a little time to recover from its six years of compulsory stagnation. Only seventeen electric-lighting Provisional Orders were applied for in 1889, but in 1890 the applications rose in a bound to 161. The new Act had opened the purse-strings of capital again, and one by one the various districts of London and the populous provincial towns were exploited by the electrical engineer. Unfortunately, the lost years could not be regained; and when the demand for electrical machinery arose in Britain, the American and Continental firms were six years ahead of the British in experience and in the development of means of production. Hence it was that our commercial rivals reaped much of the benefit of electrical progress when it really took foot again in this country. It is perhaps unnecessary to dwell on the moral of this situation

beyond remarking how clearly it shows that the British electrical manufacturer was not altogether to blame when orders for electrical machinery went abroad. No better example could well be given of how a young industry may be crippled and almost destroyed by an Act of Parliament framed with the best intentions in the world.

CHAPTER III

THE EARLY DAYS OF ELECTRIC LIGHTING
(continued)

AFTER its revival, through the passing of the Electric-Lighting Act of 1888, the electric-lighting industry led a dual life. Which aspect of its existence corresponds to the Dr. Jekyll and which to the Mr. Hyde of R. L. Stevenson's parable is a matter we do not propose to discuss. The public supply of electricity for lighting and other purposes by municipalities is only one factor, though an important one, in the recent development of municipal trading; and as that development touches many things outside the electrical industry, and is in some degree a matter of politics, it lies beyond our scope. In 1900 a Joint Committee of the Lords and Commons was appointed to consider the rights and wrongs of municipal trading, but it had not finished its labours when the session ended. Another Joint

Committee with a similar object was appointed in the 1903 session, and has issued a partial report dealing with the auditing of municipal industrial accounts. To a certain extent, we believe, the practical question is settling itself as far as the electrical industry is concerned. Compromise is the god of politics, and already a compromise between principles once hopelessly at war seems to be offering, as we shall show later, a sort of working solution of the problem whether municipal or joint-stock methods are better in electricity-supply and electric tramways. We do not say that the compromise satisfies the leaders of either party or that it is final; but it gives a *modus vivendi*, which is better for electrical progress than the antagonism of two parties engaged in the same class of enterprise. Thus, while the broad question of municipal trading is being settled on a politico-economic basis, the electrical industry is endeavouring to patch up the quarrels of its financial parents, and to go ahead as fast as the war of principles will allow it. The situation is very much that of two armies fraternizing on a frontier which is in dispute among their commanders.

As one might expect, the development of municipal electric lighting was not so rapid as that of electric lighting by companies. In 1888

municipal trading was not so common as it is now; and in any case it is the custom of local authorities, as guardians, in a sense, of the public funds, not to embark on enterprises of a novel and speculative kind. So it happened that, although local authorities could have obtained, at any time after 1882, powers to undertake electricity supply in their areas, the pioneer work was done by companies. When a certain amount of experience had been gained, and the profit-earning power of an electricity-supply business in a large town had been fairly shown, the local authorities began to apply for electric-lighting Provisional Orders.

They were further induced to do so for a rather curious reason. The Electric-Lighting Acts gave every local authority the power of veto over any company or neighbouring authority seeking powers to supply electricity in its area—that is to say, any local authority could, by simply saying 'No,' keep anybody from obtaining such powers of supply, or even from getting their application heard by the Board of Trade.

As soon as the Electric-Lighting Act of 1888 was passed, applications for Provisional Orders were made by companies in respect of several London districts and many provincial towns. The rush for these Orders awakened first the curiosity and then the self-interest of the local authorities.

When they were asked for their consent, and found that Parliament had given them an absolute power of refusal, they naturally concluded that the powers so anxiously requested were very valuable. Perhaps they exaggerated the value, but, at any rate, many of them reasoned that as so much value was attached to electric-lighting powers, they would do well to keep them for their own use. Consequently, the power of veto was liberally used, and companies seeking to carry out the provisions of the Electric-Lighting Acts found that they had to overcome, by diplomacy and by argument, a serious obstacle at the very outset of their labours.

In addition, there were two main reasons why the veto was used. The first was that many local authorities were the owners of the gasworks in their districts, and wanted, of course, to keep out a competition then regarded as almost fatal to gas lighting. The second was that, in obedience to the municipal trading movement, and to the desire to maintain full control over operations which involved the opening of streets, the local authorities wanted to have the business of electric lighting in their own hands.

As regards the first reason, the local authorities were not much better advised than the gas shareholders who sold out in the panic which Edison

caused. Experience has shown that, although electric lighting has increased in popularity, the use of gas has not diminished. On the contrary, it has steadily increased, and the growth is partly due—by a simple paradox—to the introduction of electric lighting itself. In most places where electric lamps are installed the consumer is not content with simply replacing the gas lights with electric lights of the same candle-power; the qualities of the light tempt him to a greater brilliance of illumination, so that houses and shops lit by electric light are generally much brighter than those lit by gas. A new and improved standard of illumination was thus made by electricity, just as gas had made it over oil-lamps, and oil-lamps over candles. Gas consumers were consequently led to improve their illumination up to the level of electric light by putting in larger burners or increasing their number—that is to say, by burning more gas. Further, the threat of competition led the gas companies to devote themselves heart and soul to the development of gas apparatus for heating and cooking.

These facts, aided by the pressure of public opinion in favour of the new illuminant, gradually changed the policy of local authorities who had used their power of veto, or taken out 'blocking' electric lighting orders, merely because there was

a municipal gas-supply in their districts. Nowadays it is not uncommon for a municipality to have a gas and an electricity department working with every appearance of harmony. Only in the smaller provincial towns—where there is little scope for two such methods of lighting—is the presence of municipal gasworks considered by the public as a sufficient reason for refusing entrance to an electrical company or neglecting to organize a municipal supply of electricity. And even there the vested gas interests are not always successful in their obstruction.

As regards the second reason for electric-lighting enterprise on the part of local authorities—that they, in obedience to the development of municipal trading, desired to keep so promising a monopoly in their own hands—it might have been expected that it would make itself felt first in the heart of London, which was the most likely field for a successful electric-lighting enterprise. But such was not the case. We have seen already that numerous applications for Provisional Orders in London and elsewhere had been made under the Act of 1882, and that most of them had been dropped because of the impossible conditions of that Act. When the amending Act of 1888 was passed, applications for the best London districts were made at once and were granted immediately,

before municipal ambitions in electricity supply had been awakened. For instance, electric powers were granted in 1889 (the first year of working of the Act of 1888) to the Brompton and Kensington, Charing Cross and Strand, Kensington and Knightsbridge, London Electric Supply, Metropolitan, Notting Hill, and Westminster Companies, which covered almost the whole of the inner ring of London. With one exception, the first electric-lighting Orders granted to local authorities in the London district (for St. Pancras, Hampstead, Shoreditch, and Stepney) were dated 1892; the exception was that of St. Pancras, which took out an Order under the old Act in 1883, but did not work it until 1890.

In the provinces, however, the local authorities were among the first to apply for Orders under the new Act; and a large number of towns, such as Birkenhead, Blackpool, Burnley, Bolton, Huddersfield, Hull, Lancaster, Leicester, Manchester, Nottingham, Oldham, Portsmouth, Salford, Stafford, Walsall, and Yarmouth, got their electric-lighting powers in 1890 or 1891.

This course of events led to a curious division of labour between companies and local authorities engaged in the business of electric lighting. The central areas of London are, as we have seen, in the hands of companies; the outer districts are

for the greater part in the hands of the local authorities. All the large provincial towns, with hardly an exception, are electrically lighted from municipal stations, while the smaller provincial towns are in the majority of cases supplied by companies. These broad divisions make it very difficult to form sound comparisons between the results of municipal and company working of electric-lighting stations. The conditions as regards cost of land and materials, the density of the area of supply, the nature of the demand, and so on, are very different in Westminster from what they are in Brighton, and very different again from what they are in Winchester. Circumstances alter cases; and when the accounts of municipal and company electricity-supply undertakings are put through a sort of competitive examination, marks must be taken off or added on for a score of local peculiarities before the result will satisfy an impartial examiner. When these peculiarities are forgotten, statistics may prove anything or nothing—a fact which accounts for the endlessness of discussions on the aforesaid invidious comparisons. Each undertaking must be considered on its merits, as it affects the convenience of the public and the pockets of its proprietors, whether shareholders or ratepayers. Such a detailed examination is altogether beyond our range, and

accordingly it is necessary to confine ourselves to a broad description of the conditions under which the different classes of electric-lighting business are carried on, and the general results which have been attained.

CHAPTER IV

ELECTRIC LIGHTING IN LONDON

IT is rather difficult to describe, without laying one's self open to a controversy with conflicting pioneers, which was the first electric-lighting business in this country to undertake the supply of electricity from a central station over a wide area.

As far as London is concerned, one of the first undertakings of the kind was the Kensington Court Electric Light Company, Limited, which has now become the Kensington and Knightsbridge Electric Light Company, Limited. The Kensington Court Estate belonged to the Land Securities Company, and Colonel Crompton made arrangements with that company, and raised the necessary capital of £3,000 to carry out what he called a 'house-to-house' supply of electricity for lighting purposes. As the estate possessed a subway along which the electric-lighting cables might be passed, there was no need to go to Parliament for powers,

and therefore no need to suffer the disabilities of the Act of 1882. The business was, in fact, a private installation on a large scale, and in a year's time (by the end of 1887) Colonel Crompton had shown that it was both feasible and profitable to supply a large number of houses with electricity from a single central electric generating station.

Although there was thus, at that period, no engineering obstacle to such a wholesale system of electric supply, there was plenty of discussion amongst electrical engineers as to which system of supply was the best. As most people are aware, there are various kinds of electric currents. They may be continuous or alternating—*continuous*, when the electric pulses produced by revolution of the coils of the dynamo follow each other in one direction along the wires of the electric circuit, the succession being so immensely rapid that practically a steady, continuous electric current results; *alternating*, when the electric pulses flow, first in one direction and then in the opposite direction, along the circuit with a frequency determined by the rate of revolution of the dynamo. What are known as single-phase, two-phase, three-phase, or polyphase currents are various forms of alternating current, each of which has its peculiar advantages for special purposes.

With small private electric-lighting installations

it was usual to design the plant to produce electric currents, either continuous or alternating, at the pressure (50 or 100 volts) which was then considered most suitable for the electric lamps. Occasionally a storage battery was used as an auxiliary. A storage battery is an apparatus which, after having been 'charged' by an electric current for several hours, becomes so altered in chemical composition that it can itself act as an electric battery, giving out all, or nearly all, the electrical energy put into it. These batteries are widely used now in electric automobiles, and have been employed as a stand-by in electric-lighting stations since before 1882.

The feature of the earliest electric-light installations was that the current was generated at the same pressure as it was used. With a small private house, or even with a group of houses, like the Kensington Court Estate, the distance over which the electricity has to be conveyed is very small, so that, although there is a certain drop of pressure along the electric conductor (just as the pressure of water in a pipe diminishes the more the further it has to flow), it is so slight as to be practically negligible. On the other hand, if it were intended to light an area of several square miles from a central station, some of the electric mains would be a mile or more in length; and it

would be found that, although the dynamo was producing current at a pressure of 100 volts, the resistance offered by such long conductors to the flow of the current would bring the pressure at the end of the conductor down to, say, 80 volts. A drop of this kind means a serious loss of energy, and, accordingly, one of the problems which electrical engineers set themselves to work out was how to convey electricity over long distances without any serious waste of energy.

This problem was solved by transmitting the electricity at a very high pressure. In one of the earliest 'systems,' known as the B.T.K. system, continuous current at high pressure was generated at a central station, and conveyed to several 'substations' placed at various convenient points in the area of supply, where it was used to charge accumulators which supplied current at working pressure to the area around the substations. This system—the pioneer system of 'devolution' from a central station over a large district—was first installed in 1883 by Mr. George Offor and Mr. Frank King at Colchester, which had the further distinction of being the only town where the original 'Brush babies' really got to work. The same system was adopted later by the Chelsea Electricity Supply Company, and has been employed, with variations, in other places.

In these early days, however, the most startling application of the principle of electrical transmission at high pressure was made by the pioneers of the London Electric Supply Corporation. Their idea was to choose a site near London where land was comparatively cheap, water handy, and coal available at low rates; to erect a generating station there, and to transmit electricity through cables at very high pressure into the heart of London. The site selected was at Deptford, and the work was carried out under many difficulties by Mr. Ferranti; but the project was, unfortunately, before its time. The cables of those days were not to be relied upon to carry current at 10,000 volts without leakage or without breaking down; while the transformers which were used to bring the electrical pressure down to the working pressure of 100 volts were by no means so efficient as those which are manufactured to-day. Consequently, what was excellent in principle was found to behave very badly in actual practice, and trouble followed upon trouble, until there was an almost complete breakdown.

With up-to-date plant the company is redeeming the faults of its youth, and its sponsors have now the satisfaction of seeing their methods (or the principles underlying them) become standard in the long-distance transmission of electrical energy,

None of the other electric-lighting companies had to pass through so arduous a period of pioneering, since none of them tried so bold an experiment. They put their generating stations near the centres of their areas, and followed more or less closely the example of electric-lighting stations in America and on the Continent.

It is only in London that the Board of Trade allows competition in electric lighting. As a rule, the authorities act on the principle that, as electric lighting involves the breaking up of the street surface to lay cables, and is most economically carried on by a single station supplying a wide area, it should be a monopoly, whether in the hands of a company or a municipality. An exception to the rule is made in the case of London, because London is an exception to most rules. Its inner areas are particularly dense. Within a square mile north of Charing Cross one will find, perhaps, three times as many likely customers as in a square mile of a provincial town. With a view to making a fair division of the good things of this London earth, the Board of Trade has allowed two or more companies to come into such areas.

It is, of course, a great advantage to an electric-lighting company to work in a dense area. A heavy part of its capital expenditure is in cables,

which are laid along the streets like gas mains; and if the district served be thickly populated one mile of cable will bring the company into touch with far more consumers than two miles of cable would in an open suburban area. Business develops quicker and is (other things being equal) more profitable than where long lines of mains have to be laid to connect up with a few dozen consumers. On the other hand, there are distinct disadvantages when supplying wholly within a congested district. Suitable land for generating- and sub-stations is expensive and difficult to obtain; rates and taxes are high, and costly arrangements have to be made to avoid nuisance from vibration or smoke at the generating station. That these disadvantages are not merely fanciful is shown by the recent action of the Metropolitan, St. James's and Pall Mall, Westminster, Notting Hill, and Kensington and Knightsbridge Companies. All these undertakings found, a few years ago, that their existing stations were being taxed almost to the limit of the plant which could be put into them. If the business was to continue developing, a considerable increase in the actual and potential capacity of the generating stations was necessary. The companies weighed the pros and cons very carefully; and the result was that the St. James's and Pall Mall and the Westminster

Companies combined to build a joint station outside their areas at Grove Road, Marylebone; the Notting Hill and the Kensington and Knightsbridge Companies combined in a similar arrangement for a station near Wormwood Scrubbs; and the Metropolitan Company built itself a new station at Willesden. At these stations electricity is generated at very high pressure, and transmitted through cables to substations in the areas of the companies, whence it is distributed to the consumers. Taking into account the losses inevitable in transmission, it is found to be cheaper to generate the electricity outside and transmit it over the intervening distance than to build a new station within the crowded area. The example of the pioneering London Electric Supply Corporation could not have been much more closely followed.

There are fourteen companies supplying electricity within the county of London, and fifteen local authorities possess statutory powers for the same purpose. Until recently the numbers were exactly even, but the Woolwich undertaking has passed from the hands of a company under the control of the local authority. It was purchased as a going concern at a valuation, which was £80,000. The actual capital of the undertaking was £50,000. The local authorities mentioned are Battersea, Bethnal Green, Bermondsey,

Fulham, Hackney, Hammersmith, Hampstead, Islington, Poplar, St. Pancras, Shoreditch, Southwark, Stepney, Stoke Newington, and Woolwich. Supply has begun in all cases except Bethnal Green and Stoke Newington. St. Pancras was the first to begin supply (in 1891), and it was followed by Hampstead in 1894, Islington in 1896, Hammersmith and Shoreditch in 1897, Southwark and Stepney in 1899, Poplar in 1900, Battersea, Fulham, and Hackney in 1901, and Bermondsey in 1902. At Fulham and Shoreditch a dust destructor is attached to the generating station; the local refuse is consumed in furnaces at a high temperature, and the heat given off assists in the raising of steam.

It is clear at a glance that none of these districts is really comparable with the central districts of London as a field for electricity supply. While, therefore, any comparisons with older established company undertakings in the heart of London would be useless, it may be interesting to give some figures relating to the local authorities' undertakings themselves. Woolwich is omitted from the calculation, since its transfer to the local authority is so very recent.

According to a return made by Mr. Edgar Harper, Statistical Officer of the London County Council, the local authorities have borrowed in

all (up to the end of 1901) £2,286,292, at an average rate of 3·26 per cent., for their electric-lighting enterprises. When a local authority borrows money for such a purpose, it is compelled to repay the capital, by means of a sinking fund, over a period, usually, of twenty-five years. Under that arrangement the local authorities have repaid £81,406 of the amount borrowed. The proportion of total expenditure to revenue is 67 per cent.; and after payment of interest on the borrowed capital there was a surplus at the end of 1902 of £24,324. Out of that sum, £23,926 had to come for sinking fund; and after further deductions of £3,781 (0·17 per cent. of the net capital expenditure) for depreciation, and £3,741 for reserve, there is a debit balance of £7,124.

The table opposite gives the main figures relating to the various electric-lighting companies in London.

Some explanation may be given of the less satisfactory cases in this table, as illustrating the unequal nature of electrical enterprise. The Blackheath and Greenwich Company is, of course, a comparatively new one, and in its earliest years it was not worked so successfully as many other undertakings have been in similar districts; last year, however, it was quite in a position, as far as funds went, to pay a dividend on the ordinary

Name of Company.	Commencement of Supply.	Total Called-up Capital.	Ordinary Dividend (Per Cent.).						
			1896.	1897.	1898.	1899.	1900.	1901.	1902.
Blackheath and Greenwich	1900	£ 201,200	—	—	—	nil.	nil.	nil.	nil.
Brompton and Kensington	1889	200,000	nil.	4	6	6	6	8	8
Charing Cross and Strand	1891	860,677	6	7	8	9	9	10	10
Chelsea	1889	402,680	5	6	6	6	5½	4	4½
City of London ...	1891	1,805,950	7	10	6	4	nil.	5	5
County of London ...	1892	1,033,279	nil.	nil.	nil.	4	4	4	4
Crystal Palace District	1893	116,684	nil.	nil.	nil.	nil.	nil.	nil.	nil.
Kensington and Knightsbridge ...	1887	295,000	7	10	10	11	12	10	10
London	1885	832,200	nil.	nil.	nil.	nil.	nil.	nil.	nil.
Metropolitan	1889	1,470,000	5	6	5	5	6	6½	7¼
Notting Hill	1891	180,800	4	6	6	7	7	6	6
St. James's and Pall Mall	1889	450,000	10½	14½	14½	14½	14½	14½	14½
South London ...	1899	325,000	—	nil.	nil.	nil.	nil.	nil.	1¾
Westminster	1890	797,600	9	12	12	13	10½	10½	12
Woolwich	1893	35,000	2	nil.	nil.	2½	5	6	[sold]

shares, but the directors preferred a conservative policy in view of large extensions of the company's operations into neighbouring districts. Several of the County of London Company's areas are suburban in character, and consequently more slow in development; hence the steady 4 per cent. dividend. The Crystal Palace District undertaking was an ambitious scheme for supplying several adjacent districts from one station (the prototype of the modern electric-power scheme), but it had a very chequered financial career in its youthful days. The case of the London Company has already been explained. The South London Company is in the peculiar position of being the only London electric-lighting company which possesses a dust destructor. The company took over, at a heavy price, an order granted to the old Vestry of Lambeth, and it agreed with the Vestry to destroy dustbin refuse at a charge of 11½d. per ton, and to maintain twenty-five public arc-lamps free of charge. The Vestry, or its successor, the Borough Council, was so vigorous in summoning the company for causing a nuisance with the dust destructor that it had to be stopped. These causes, combined with others, have delayed the progress of the undertaking to financial prosperity.

With regard to the future of electric lighting in

London, it is difficult to speak with certainty. All the Orders granted to the companies fall out in forty-two years after 1881—that is to say, in 1923—and at that date the local authorities may purchase the undertakings in their areas at almost scrap-iron value. Most of the companies are making definite provision, by means of a depreciation fund, for the final purchase at low capital value in 1923; but whether matters will reach that stage is not certain. It is well known that the London County Council—or, at least, a section of it—is ambitious to take the whole of the electric lighting of London into its own hands. That would be a stupendous undertaking, involving a preliminary outlay of certainly not less than fifteen millions of money, and necessitating further expenditure for development amounting in a few years' time to several millions more. So far, Parliament has not looked with favour upon the scheme, which, in view of the engineering difficulties in the way of amalgamating the various undertakings (due to differences in the system of supply), does not possess convincing advantages.

CHAPTER V

ELECTRIC LIGHTING IN THE PROVINCES

ALTHOUGH the electric lighting of most of the important provincial towns is now conducted by the local authorities, the pioneer undertakings were, as has been mentioned already, organized by companies. In Eastbourne and Hastings, for instance, companies started supply in a small way as early as 1882; Colchester was another early starter, and Liverpool followed in 1883. But the majority of towns took out their own Orders in 1890 and 1891, and started supplying electricity a few years later. In towns such as Birmingham, Bath, Leeds, Glasgow, and Liverpool, where there was at that time a company at work, the Corporation got Parliamentary sanction to buy up the electric-lighting business, and run it under municipal ownership.

There are now about 200 of such municipal electricity-supply undertakings in the kingdom,

and loans to nearly £20,000,000 have been authorized in connection with them. The conditions on which these loans are granted place the undertakings on a somewhat different financial footing from companies carrying on the same class of business. Like all municipal loans, the capital has to be redeemed by a sinking fund, and the period allowed for redemption is usually twenty-five years. From the time of borrowing, therefore, the undertaking has to bear the payment of interest and also of sinking fund, the two together making a demand of about 6 per cent. on the capital expended. During the first two or three years, when the demand is being built up and a paying business got together, the revenue is sometimes quite insufficient to meet both interest and sinking fund; the deficits so caused have then to be met out of the rates.

With a company, on the other hand, the bulk of the capital is raised by public subscription for shares, on which a dividend is paid when the undertaking is in a position to afford it. A small portion of the capital may be raised (usually when the business has got under way) in the form of debentures bearing a fixed interest; and the revenue available during the first years of working is usually quite sufficient to cover the 4½ or 5 per cent. of interest on a quarter or so of the

total capital. The joint-stock method of finance clearly has its advantages in a business which does not at once begin to earn a solid revenue. Municipal authorities, recognising this, have expressed a wish—with which the Government does not yet appear to sympathize—to be relieved of the sinking-fund payments during the first few years of working.

According to the latest available official returns (for 1900), the total result of all the municipal electric-lighting undertakings in the kingdom, after payment of interest and sinking fund, and after deducting the irregular allowances made for reserve and depreciation, was a loss of £102,931 on a capital expenditure of £14,943,122. Whether the profits made in particular cases may or may not be regarded as a satisfactory margin of success is usually a matter of local controversy, which is complicated by a more general controversy regarding the sufficiency, or otherwise, of the provision made for depreciation. Some authorities hold that the sinking fund, which redeems the capital in twenty-five years, is equivalent to a depreciation fund intended to provide for the wasting of capital through the wearing-out and antiquation of machinery. Other authorities hold that the sinking fund has nothing whatever to do with depreciation of plant, that its payment is merely

a condition on which the money for the business is borrowed, and that its intention is to enable the public to obtain an undertaking *debt free* at the end of a certain period, thus preventing in some degree the overwhelming growth of public indebtedness. From this point of view, provision for the wasting value of machinery should be made quite independently of any sinking fund arrangements whatsoever.

Municipal undertakings as a whole have no definite policy in this matter, just as companies have no uniform plan in respect of depreciation and reserve funds;* but it is clear that estimates of the stability of municipal electrical finance must depend to a great extent upon how this question of actuarial principle is decided. Without adopting a dogmatic attitude, it may be said that in accountancy the last laugh is usually with the purist.

A large provincial town is generally regarded as the most favourable field for electric lighting; the small provincial town is, of course, very much less attractive to the electrical engineer. Apart from the fact that in such towns people are usually less ready to change their habits than in large and active industrial cities, one can readily understand that to make the business of electric

* Electric-lighting companies' accounts are, however, subject to Board of Trade audit.

lighting successful in small towns of ten or fifteen thousand inhabitants an extra amount of 'push' and an extra measure of economy in working are necessary.

As regards economy in working, that is secured by the familiar industrial process of *centralization*. The companies which undertake this class of work od not, as a rule, follow the model of 'one-ship companies'; they take out Provisional Orders for several different towns, and control the working of these Orders from headquarters.

A typical instance is that of Edmundson's Electricity Corporation, Limited. In the old days this company (or its lineal predecessor) used to contract for electrical installations in large private houses—a branch of business which, it is worth noting, is still brisk and profitable. About the year 1888 it extended its operations to the lighting of towns. Folkestone, Winchester, Salisbury, and Ventnor were among the first places to be tackled, and now the corporation is engaged in lighting close upon forty towns, all of small or moderate size. In most cases the Provisional Orders are taken out in the name of a local company in which the parent corporation holds a controlling interest. All the Parliamentary, financial, and preliminary engineering work is done at the head office in London bv a special trained staff. The

expense of that work usually falls very heavily on a single small undertaking; but where it is spread over several undertakings of the same character, each of them obtains the benefit of first-class expert advice at a fraction of the price it would have to pay if it had to engage consulting engineers, etc., of its own. Moreover, by doing business on a large scale, the parent corporation is able to make very favourable financial arrangements for its babies. It is able to find capital much more readily and cheaply, for instance. Recently it obtained electric-lighting Provisional Orders for Hawick, Newton Abbott, Godalming, Glossop, Grantham, Berwick-on-Tweed, Bishop Auckland, Redruth, Caterham, Stamford, Dartmouth, Weybridge, Dunblane, and Newbury, in the name of the Urban Electric Supply Company, Limited. With that company the Edmundson Corporation contracted to undertake the construction, supervision, and management (until the end of 1910) of the various electric-lighting stations, and to guarantee for a like period a dividend of 5 per cent. on the preference shares, and of not less than 5 per cent. on the ordinary shares, of the Urban Company. Clearly this parental guarantee smooths the financial path of the Urban Company, and gives each of these little undertakings as broad a basis, commercially

speaking, as an electric-lighting business on a large scale.

In a similar way the local undertakings are managed very cheaply. Their boards of directors are made up of officials or directors of the parent company, with one or two local men of position, thus keeping directors' fees at a moderate level. The control of all the local stations is centred at the head office, and each month the resident engineer of every station forwards to London a filled-up form, which supplies a complete record of business in his particular district. The number of units sold, amount of coal burned, amount spent in wages, number of new customers, number of new lamps connected—all such data, down to the minutest detail, are included. Thus the headquarters staff can see, as the weeks go on, how each station is succeeding, or in what points it is not progressing properly. Thus, also, the headquarters staff accumulates a vast amount of valuable experience, and is able to forecast how much business is to be expected to grow in certain towns. Under this system, therefore, while each local undertaking has the constant benefit of first-class engineers' advice at a small cost, it is able to run its business successfully with a resident engineer who does the work and earns the salary of an assistant.

The policy of centralization has other arguments in its favour. Practice makes perfection, and after a company has floated and managed several electric-lighting undertakings it finds out many ways of saving money. It also becomes skilful in developing the demand for electric light. This is by no means an easy matter, because the majority of people (whatever they are in politics) are conservative in their habits. They are particularly slow to change in this case, because they have got the idea that electric light is costly, and because they do not like to go to the expense of installing the wires and lamps. If a man is merely a tenant, he does not want to spend money for benefits which he may enjoy only for a short term. The landlord hesitates to pay the bill for him, since he knows that what he does for one tenant in a row of houses all the neighbours will demand as their right. Moreover, if the tenant persuades the landlord to 'wire' his house for electric light, the landlord usually atones for a momentary lapse into good nature by raising the rent. Where a man owns the house he lives in, it is the cost of 'wiring' that usually frightens him. He thinks electric light a very excellent invention, but for a man with a growing family and a stationary income the wiring contractor's bill is a serious obstacle.

These practical difficulties are being got over in various ways. Efforts are being made to produce a cheap but efficient line of electric fittings so as to reduce the cost of changing from gas to electric light. Various systems of 'free wiring' have been introduced to allow the change to be made without any initial cost to the consumer. Municipalities are not allowed to carry on this business, as it is regarded by the powers that be as a more or less speculative trade not essential to the sale of electric light. If they want their customers to get the benefit of 'free wiring,' they have to call in the aid of a wiring contractor who will undertake the risks involved.

'Free wiring' is, of course, not really free. Electric-lighting companies are not charitable institutions. The proposal usually made to an intending consumer is that the company will fit his house with wires and lamps, and make no *initial* charge. A rental—say, of 4½d. per lamp per quarter, as in the case of some Edmundson companies—is charged, and the wires and fittings remain the property of the company. The customer can make a trial for one year, with no obligation to continue use, and he has the chance of buying the installation at any time. If the purchase be made within the first year no rental is charged. Sometimes the option is given of

taking the installation on the hire-purchase system. The company, for instance, takes payment over a period of three, seven, ten, or fourteen years, charging 5 per cent. interest on outstanding amounts.

An interesting variation of the free-wiring system has recently been introduced. The company offers to instal six lamps free of all charge for a six months' trial, on the condition that it is allowed to choose the position of the lamps. The householder pays simply for the current he uses during the trial period, at the end of which he is free to adopt the new light or to tell the company to remove its wires and put the house as it was before. In this way people are readily induced to give electric light a trial, and it is usually found that electric light, once used, is always used. While the company has to lay out money for a short time without interest on the trial installation, it is generally rewarded by obtaining a new customer, who purchases the six-lamp installation and orders the whole of his house to be wired. Something of the wisdom of the serpent is mixed in with this method of popularizing electric light, but the device would be hopeless from the point of view of business if the cleanliness, healthiness, safety, and beauty of electric light were not convincing when once they had been experienced.

The 'on approval' method also gives the house-

holder the chance of discovering that electric light is by no means so expensive as rumour would have him believe. Another way of demonstrating this fact has been employed by the Edmundson and other companies with considerable effect. The method is to arrange for electric lighting in a row, say, of new workmen's cottages. Penny-in-the-slot or shilling-in-the-slot meters are used in conjunction with 'free wiring,' and the workman finds that his lighting bill comes to about 1s. per week, which covers the rent of the wires and of the meters. (A shilling dropped into the meter will keep two lamps alight for four hours each night for a week.) The workmen are good customers, but the moral effect on the villa and other regions of the town is a big profit in itself. When the owner of a house, shop, or mansion sees that John Smith has electric light in his cottage, and is still apparently solvent, he becomes easy prey to the electric - lighting canvasser. Clearly it is worth while for the pioneers of a new light to study human nature.

Another drawback to the ready adoption of electric light is the complicated system of charging often used. In electricity-supply meters are used to register the amount of current consumed, just as gas meters record the consumption of gas. But the parallel ceases here, because the gas is

stored in reservoirs and the electricity is generated and supplied as required by the varying demand. Thus the machinery at an electric generating station lies almost idle during the greater part of the day; the demand for light begins at dusk, rises rapidly to a 'peak' between dusk

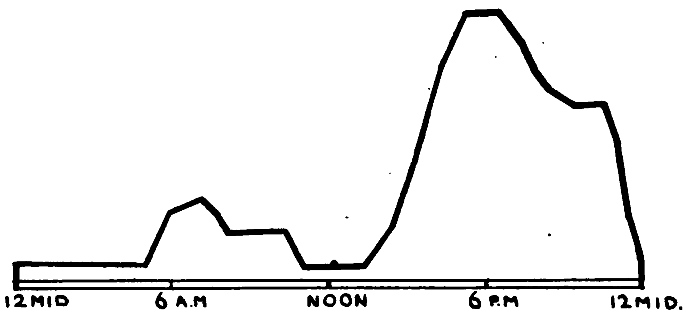


FIG. 1.—This curve represents the daily 'lighting load' in a provincial town. The small 'peak' between 6 a.m. and noon is due to the charging of storage batteries, which act as a stand-by at the supply station. The real demand comes on suddenly in the afternoon, rising to its summit after six o'clock, and falling away towards midnight, when nearly all lights are turned out. Thus, between midnight and 5 p.m. of the following day there is practically no demand, and the machinery is almost idle.

and bedtime, and sinks to nearly nothing during the remainder of the night (see Fig. 1). Machinery has to be provided to meet the maximum demand when it comes, but for many hours out of the twenty-four the powers of the generating plant are only partly used.

It is not difficult to see that, under such circumstances, it is cheaper (both in first cost and in daily working) to supply electricity for one lamp burning ten hours on end than for ten lamps burning for one hour. The total quantity of electricity used is the same in both cases, but in the second case bigger machinery would be wanted, and it would be productive for only a very short period. Hence the electric-light company is always hankering after 'long-hour consumers'—people who will burn even a few lamps steadily for a good spell, and thus help to keep the dynamos at the generating station working long under a fairly even load. Public-houses, late-closing shops, public libraries, clubs, etc., belong to this popular group. 'Short-hour consumers,' on the other hand, require the same amount of plant for their service, but are by no means so remunerative.

An attempt has been made to level up this difference—to make the short-hour consumer pay a fair share of the extra cost he involves, and to give the long-hour consumer the benefit of being an economical man to supply. The method adopted is called the 'maximum demand system' of charging. This system is excellent in theory, but a trifle difficult of comprehension by the average man. A writer who imitates Mr. Dooley

in the columns of the *Electrical Times* has dubbed it the 'mixemup-anbedam'd system.' Perhaps, however, the above explanation will suggest why it is that steady consumers get the full advantage of a liberal rebate, while the will-o'-the-wisp consumer does not.

An instrument is used to indicate the 'maximum demand' in each house, being the current required by the largest number of lamps alight at any one time. For any quantity of current up to the amount which would have been used if the maximum demand had continued 90 or 100 hours per quarter a rate of, say, sevenpence or eightpence per unit is charged.* For any quantity beyond that a rate of say, threepence per unit is charged. Therefore, if a man keeps his maximum demand near his average demand—that is to say, if he burns about the same number of lamps fairly steadily—he will get his current much cheaper than the man who has all his house aglow for only one hour or so in the evening.

The following table, which is extracted from a circular issued by Edmundson's Electricity Corporation in connection with electricity-supply in

* The unit is officially fixed by the Board of Trade a sa 'kilowatt hour,' which is a kilowatt of electrical energy acting for one hour. A 16 candle-power lamp, burning for sixteen hours, consumes about 1 unit.

Hamilton, shows how, under the maximum demand system, the average cost of current diminishes with the lengthened daily use of the light:

Class of Rooms and Premises in which the Lamps are Used.	Number of Hours the Lamps are Used per Quarter.	Usual Time of Extinguishing Lamps Lighted at Dusk.	Average Rate charged per Unit Consumed during the Year.	Approx. Equivalent Price of Gas, per 1,000 Cubic Feet.
Offices, early-closing shops, and occasionally-used rooms ...	91	7 p.m.	7d.	4s. 1d.
Shop windows ...	182	8 p.m.	5d.	2s. 11d.
Interior of shops ...	273	9 p.m.	$4\frac{1}{3}$d.	2s. 6d.
Sitting-rooms, kitchens, basements, and late-closing shops ...	365	10 p.m.	4d.	2s. 4d.
Hotels, restaurants, and public-houses ...	456	11 p.m.	$3\frac{4}{5}$d.	2s. 2d.
Outside lamps, dark business premises, and basements ...	912	Dawn, or used all day long.	$3\frac{2}{3}$d.	2s.

Another system of charging, with the same object in view, is that by which the electricity used during a certain portion of the day is charged at a high rate, and that used during other times at a low rate. A 'time-switch' or 'two-rate meter' is employed to separate the two periods. This system is a rough-and-ready approximation to the maximum demand system, and has the advantage of being easily explained to the 'man in the street.' Many people, after they have had the theory of the

maximum demand system clearly explained to them, go away nursing a firm conviction that it is a subtle form of robbery devised by an unholy combination of unscrupulous company promoters and unprincipled municipal electricity committees. The difficulties of convincing explanation are so great that some electric-light companies prefer to adopt a 'flat rate,' or uniform charge of fivepence or so per unit, to all consumers, and wink at the inequity of the arrangement.

In spite of human inertia, of human nature, and in spite of all other obstacles referred to, electric lighting is a progressive industry. The large provincial towns under municipal control show unabated progress in the development of demand; the smaller provincial towns, whether enjoying the economies of combination under the Edmundson, Crompton, and other parental régimes, or forming independent units, display on a smaller scale the same dogged advance. And it is found that the profitableness of the business is progressive—that not only do new consumers come in year by year, but as the business grows it is possible to earn a wider margin of profit without increasing (and even with diminishing) the charges made. While the dividends earned are not great, they are usually on the up grade, and offer an attraction to investors which ought to be as great as, though of

a different quality from, the attraction of a highly speculative investment.

It is important to note that the Board of Trade has allowed the wind of expropriation to be tempered to many of the lambs of the electric-lighting industry. Terms have frequently been arranged between companies and local authorities which secure to the electric-lighting undertaking the return of its fair market-value at the end of certain periods. In Folkestone, to take one illustration, the Corporation has the right to buy the electric-lighting undertaking at the end of twenty-two years from July, 1896, upon paying the capital expended plus 10 per cent., or after twenty-nine years upon paying the capital expended plus 5 per cent. Such special arrangements are allowed under the Electric Lighting (Amendment) Act, 1888, but have to be sanctioned by the Board of Trade.

A new electric-lighting Bill was drafted in the 1903 session by the Board of Trade, but was not introduced, owing to pressure of other Parliamentary business. Most of its provisions related to the supply of electricity for power—a subject discussed in later chapters. Its main point as regards electric lighting in particular was that it definitely repealed the right of veto possessed by local authorities under former Acts, giving the

Company.	Total Capital Subscribed.	Ordinary Dividend. 1900.	1901.	1902.
	£	%	%	%
Bournemouth and Poole Electricity Supply Co., Ltd.	295,000	5	7	8
Cambridge Electric Supply Co.	66,478	7	7	7
Edmundson's Electricity Corporation, Ltd.	580,000	7	7	7
Folkestone Electricity Supply Co., Ltd. ...	100,000	4	4½	5
Hove Electric Lighting Co., Ltd.	80,000	8	8	8½
Liverpool District Lighting Co., Ltd. ...	49,880	nil.	3½	5
Newcastle and District Electric Lighting Co., Ltd.	210,000	8½	8½	8½
Newcastle-upon-Tyne Electric Supply Co., Ltd.	539,700	8	8	8
Northampton Electric Light and Power Co., Ltd.	72,732	2	3½	4½
Oxford Electric Co., Ltd.	120,000	5	5	5½
Richmond (Surrey) Electric Light and Power Co., Ltd. ...	74,180	5	6	7
Salisbury Electric Light and Supply Co., Ltd.	23,655	3	4	5
Scarborough Electric Supply Co., Ltd. ...	63,995	6½	7	7
Winchester Electric Light and Power Co., Ltd.	58,100	3	5	5
Windsor Electrical Installation Co., Ltd. ...	62,500	8	8	8

Board of Trade full power to hear and deal with the objections raised by local authorities against electric-lighting proposals relating to their areas.

The table on p. 65 of representative established companies gives a general idea of the financial nature of electric lighting in provincial towns, most of them being of small size.

As time goes on, the supply of electricity for lighting purposes is becoming more and more closely identified with the supply for traction and power purposes. To see how that identification has come about, and what effect it will have on electric-lighting business and the electrical industry generally, it will be necessary to trace the growth of the traction and power branches.

CHAPTER VI

THE EARLY DAYS OF ELECTRIC TRACTION

IN the 'Manual of Electrical Undertakings' there is published a chronological list of electric railways, tramways, and light railways in the British Isles. The list as a whole is interesting. The first part, which we reproduce, is especially so. The dates given are those of the commencement of electrical working on each system:

Portrush (Giant's Causeway)	1883
Brighton Beach	1883
Blackpool (Corporation)	1884
Bessbrook and Newry	1885
Ryde Pier (Isle of Wight)	1886
Birmingham	1890
Southend Pier (Corporation)	1890
Guernsey Railway	1891
Liverpool Overhead Railway	1893
South Staffordshire	1893
Douglas-Laxey (Isle of Man)	1894
Bristol	1895
Coventry	1895
Snaefell Mountain Railway	1895

Reading down the list further, we find that four new electric-traction systems started working in 1896, two in 1897, nine in 1898, twelve in 1899, twelve in 1900, twenty-five in 1901, and eleven in 1902. Here we have a bird's-eye view of the development of the electric-traction industry. Its peculiarities are the sort of false start made in the early eighties, followed by a blank, which in turn was followed by a slow growth, until a spurt took place in 1898 and succeeding years. These variations were not due to mere chance. They had their causes—causes which are still affecting the industry.

Nearly all of those lines which took part in the 'false start' were electric railways, not tramways. The use of electric power to haul cars was first demonstrated by Messrs. Siemens in 1879; but although an electric tramway on the overhead system was one of the features of the Paris Exhibition of 1881, public opinion was destined to take many years to get quite accustomed to 'live' electric conductors suspended overhead. Consequently, the first application of electric power to traction purposes was made on railways, where trespassers went at their peril. These early experiments, however, proved the value of the new motive power. Electrical engineers soon began to consider seriously, as a

practical matter, the substitution of electric for animal traction on the various tramway systems in the country.

This proved to be a more complicated business than merely having an auction sale of the horses, converting the old horse-cars into summer-houses, and buying so much electrical plant. The engineers found they had to deal with the troublesome effect of a Tramways Act passed in 1870, long before electric traction had been thought about. The story of this Act is a long and rather uninteresting one (at least to the general public, which does not get enthusiastic about statutes). It is possible to tell it with a certain element of pathos, but it is wholly devoid of humour. One or two main points, however, will serve to show why the development of electric tramways in this country was delayed, even as the electric-lighting clock was stopped for close on ten years.

The Tramways Act was, in fact, the natural father of the Electric Lighting Act of 1882, and both father and son bore the same blemishes of character. Both upheld the principle of twenty-one years' tenure, and of compulsory purchase by the local authority at the end of that short term at scrap-iron value. In 1870 the result of these conditions was not foreseen. Horse tramways were freely promoted in most populous towns,

and because they began to earn money as soon as they started running (after the happy manner of tramways), their owners did not worry much about the future. It was not until the tramways became middle-aged, so to speak, that tramway directors began to think of the approaching end and to look solemn. Then they realized their unhappy position. With only a few years to live, and with only the prospect of a partial financial salvation under compulsory purchase, it was commercially impossible for the proprietors to spend large sums of money in improving their tramway service and maintaining their plant. Each year it became more necessary to scrape and save every penny; each year the cars became more dilapidated, the track more badly kept, and the horses more melancholy. Then the public, in ignorance of the obscure Tramways Act, began to call the tramway companies by unholy names.

At this interesting stage electric traction came on the scene. Unhappily, it was like the offer of an expensive divorce to a pauper married to a shrew. The tramway companies could not afford electric traction. They could not even afford new coats of paint for dingy cars; and electric traction, with its costly generating station, new track, expensive equipment and cars, was quite out of the question. The public promptly dubbed

the companies as backward, and called upon their local councils and corporations to rid them of the old horse tramways, and give them new electric ones under municipal control. In this way discontent with dying tramway companies gave the first impetus to municipal tramways.

Nevertheless, the local authorities did not act at once. To begin with, they had to be cautious about adopting a novel system of traction. Then they knew that by waiting till the end of the tramway tenures they could force the companies to sell at scrap-iron value, whereas, if they bought the companies out beforehand, they would have had to pay fair market value for the business as a going concern. A large number of tramway concessions had been granted soon after 1870, so that the periods began to fall out in the early nineties. Consequently, electric-traction development was delayed until then, and in some cases beyond that period, owing to the hesitation of local authorities in adopting electric traction.

From about this time onwards the electric-traction industry led the same sort of dual life as the electric-lighting industry—partly under company and partly under municipal control. As a rule, the electrification of horse tramways under company control was made possible by the local authority agreeing to postpone compulsory pur-

chase until a time far enough off to justify the heavy capital expenditure on electrical equipment. This was done, for instance, in the cases of Bristol, South Staffordshire, and many other districts where company electric tramways are now running. However, as the local authority possessed an absolute right of veto (on which the veto of the Electric Lighting Acts was modelled), the companies were wholly at the mercy of municipalities which were pressed on all sides to 'municipalize' their tramways as soon as the old periods of tenure expired.

For these simple reasons electric tramway enterprise in Britain was delayed. America and the Continent got ahead of us, just as they had done in the case of electric lighting. Playing second fiddle in the orchestra of progress is not a very glorious proceeding; and it is as well to understand that the reasons why we did not play first fiddle or lead the whole orchestra are to be sought among Blue Books and Acts of Parliament, and not in the supposed degeneracy of our engineers and capitalists.

How the duality of tramway control has affected the traction industry will be considered in the next chapter, particularly in relation to what are now known as 'inter-urban' tramways. As a preliminary to that, we must touch upon the

causes of the conquest which electricity has made in the traction world.

Shortly after the invention of the commercial dynamo, it was discovered that the function of that machine could be reversed. When forcibly made to revolve, the dynamo produced electric current; when electric current was led into it, the dynamo forcibly revolved. In the one case, rotary motion was converted into electrical energy; in the other case, electrical energy was converted into rotary motion. The dynamo, in short, was able to play the part of generator or motor as required.

Electrical engineers were not slow to see how this discovery could be applied. They saw that they could arrange to have a dynamo generating current which would be carried on wires for a considerable distance, and used to operate electric motors in mills, factories, and so on. From that it was an easy step to attaching the motors to the axles of a car, and thus propelling it. Here, however, a new problem arose—that of supplying the electric current continuously to a tramway car in motion.

Three answers to the problem have been devised. The first is the familiar 'overhead system,' in which the wire carrying the current is suspended about 20 feet above the tramway track. Each

car has a trolley-pole, the end of which presses against the overhead wire and slides along it. The current passes through this trolley-pole down through the 'controller,' by which the motor man regulates the speed of the car, thence to the motors underneath the car (causing them to revolve), through them and the wheels down to the rails. The rails are specially joined up to carry the 'return current' back to the generating station, thus completing the electrical circuit.

This system is the simplest and cheapest; and the old objections to it, on the grounds of ugliness and danger, are now so fully overcome that it is practically the standard system in all countries. As far as England is concerned, only London and Bournemouth have samples of the second solution—that of the 'conduit' system. There all the 'live' electric conductors are placed underground in a concrete trench, built in the middle or side of the tramway track, and get-at-able only through a narrow slot on the surface, like the slot of a cable tramway. A 'skate' hangs from the car through this slot, and makes contact with the electric conductors in the trench. While this system has the advantage of getting rid of all exposed wires, it is so expensive to construct and maintain in good working order that it is commercially possible only in crowded cities, where the traffic is very

heavy. It costs about £14,000 per mile of single track (independent of the power-house and cable expenditure), as against the £7,496 of the trolley or overhead system. Consequently, it has been adopted only in the heart of London, save for the case of Bournemouth, where the overhead wires were objected to for alleged æsthetic reasons. In America and the Continent it has been used in a minority of cases.

The third solution—that of the surface-contact system—is also rather rare. Many variations of it have been invented, but, beyond a few samples on the Continent and a solitary English installation at Wolverhampton, it is commercially a stranger. Its title partly explains its method. The necessary electrical connection is not made with continuous live conductors, but with a series of 'studs' placed at intervals of several feet apart, and almost flush with the surface of the track. A long metal brush or skate hangs underneath the car and touches the studs, which are in connection with underground electric cables. Various arrangements are made to insure that all the studs not safely covered by the car are electrically 'dead,' and therefore harmless to horses and pedestrians. As the car passes along the track, each stud in succession automatically becomes 'live' and feeds the motors with current, becoming

automatically 'dead' when the car leaves it behind. This system is more costly than the overhead, and less expensive than the conduit system. For various reasons—technical and otherwise—it has not yet been able to oust either of its rivals.

Now we come to the commercial aspect of these technical descriptions of electric-traction systems. How is it that electricity on tramways has been able to supersede horse and steam traction? In first cost it is not cheaper; in fact, an electric tramway system costs much more to build and equip than either a horse or a steam tramway. Its advantages must lie, therefore, in economy of working. It must be able to do the actual work of carrying passengers cheaper and better than either animal or steam power.

The secret of the success of electric traction lies in the economical way in which the power required for transport purposes is used. A horse tramway has to maintain a certain stud of horses—to feed practically the same number of power-producing animals, no matter how much or how little traffic is being carried day by day. Moreover, the actual work of a horse tramway is done by about one-fifth of the horses, while the other four-fifths are resting or feeding. A steam tramway has to build its locomotives big enough and heavy enough to haul a full car up the steepest gradient on the

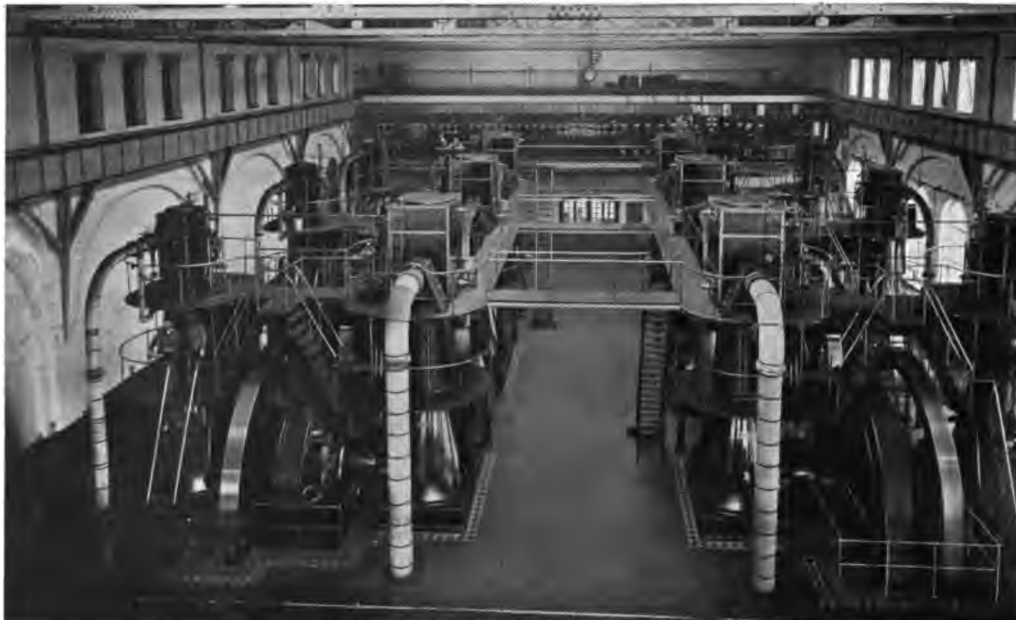
line. Both systems, that is to say, have to maintain continually their *maximum* amount of power during continual variations in the volume of traffic. The electric system is more happily placed. With it the generating station produces at each moment just as much power as is actually required, and each car uses at each moment just as much current as it requires. If the cars are half empty, the consumption of electrical energy is correspondingly slight; if the cars are all running full, the power station responds to the demand made upon it while that demand lasts.

The resulting working economy is no mere matter of theory or of paper calculation. Plenty of cases could be mentioned where horse tramways have, when 'converted' to electric traction, passed from financial failure to success. In all such cases, of course, there has been a tremendous increase in traffic, due to the more rapid and frequent service of improved cars given under electric traction, but there has been at the same time a great reduction in the *proportion* of expenses to receipts. While a horse tramway had to spend about £80 or more to earn £100, an electric tramway will spend only about £60. For instance, when a Buenos Ayres tramway was worked by horses, the percentage of expenses to receipts

was 80. When the system was converted to electric traction, the percentage dropped to 57.

Because of this economy in working, electric tramways are able to give a much better service than horse, steam, or any other kind, and at much lower fares.* Since no other mode of transport makes use of the principle of generating at a central source all the power required and distributing it over a whole system, to be used as and when required, electric traction has supreme advantages. This principle explains the financial failure of a fourth method of electric traction—that by 'accumulator cars.' Under that system, each car is a self-contained unit, with a charged electric storage battery and motors. Many engineers have valiantly tried to wring success from that ungrateful system. They have always been disappointed, because the system embodied many of the disadvantages of the old steam and other systems. When a car has to be built to carry its own power-generating apparatus, it is like a traveller who has to carry provisions for a long journey on his back. He would get along much better if he could travel light, and take his meals at wayside inns as and when he wanted them.

* The London County Council tramways, where the conduit system has been adopted, are the only exceptions.



A MODERN ELECTRIC GENERATING STATION

The Ringsend Road Power Station of the Dublin United Tramways Company, equipped with electrical plant by the British Thomson-Houston Company Limited.

CHAPTER VII

THE DEVELOPMENT OF ELECTRIC INTER-URBAN TRAMWAYS

THOUGH the term 'conversion,' as applied to the change from horse to electric traction on a tramway, is almost a slang expression, it is really very appropriate. For not only does a converted tramway, like a converted soul, enter into a new kind of existence, but its whole character likewise becomes radically altered. There is truth in the paradox that an electrified horse tramway is something more than a horse tramway electrified.

The difference lies in the widening of the actual scope of a tramway system through electrification. The horse is a noble animal, but he has his limitations; and if long distances have to be covered under horse traction, relays of horses must be provided. The expense of that arrangement, combined with the slow pace of horse cars, resulted in

the operations of horse tramways being confined to restricted areas. Very often they were limited to a single district, picking up the merely local or street-corner traffic.

With electric tramways it is quite another story. The speed of electric cars is limited only by Board of Trade regulations for the safety of pedestrian and other street traffic. The range of an electric tramway system is limited mainly by the scope of traffic demands. The distance over which, by means of high-tension currents, electric power can be economically distributed is so great that a wide network of lines can be fed from a single generating station. For instance, the London United Tramways run from Hammersmith to Southall and to Hampton Court; extensions beyond these wide limits are already authorized. All the power to operate that extensive system is generated at a single power station at Chiswick.

Thus the adoption of electric traction gave tramway systems freedom to spread. They spread from the towns into remote suburbs, and thence to neighbouring towns, linking up with tramway systems there. In short, from being *urban*, they became *inter-urban*, and in doing so they greatly increased their usefulness and their troubles at the same time.

The tale of their troubles is rather an involved one, not to be fully told without a long disquisition on tramway legislation and the thorny question of municipal trading. However, a glance at the history of two or three typical inter-urban tramway systems will be enough to show how the electric-traction industry has been carried on in England, and what its future is likely to be.

Apart from the large municipal systems, which are of the first-class urban type, the London United electric tramway system is one of the finest in the country. It affords a typical case of an inter-urban system built up with a converted horse tramway as a nucleus. Many readers will remember the ancient horse cars which used to wend their slow and stately way from Hammersmith to Kew Bridge. They presented the always pathetic spectacle of a tramway undertaking with one foot in the grave. The year 1890 saw them near the end of their tenure, with nobody to take an interest in them, save, perhaps, the local authorities, which expected to buy them up at a scrap-iron price. However, the immense possibilities of the system when electrified and extended were not altogether overlooked. About the year 1893 Mr. George White and others, who were then converting the Bristol tramways to electric traction, formed a company to buy up the old Kew

tramways. They did so on the chance that they would be able to persuade the local authorities to grant new periods of tenure, in order that the tramways might be electrified at once and extended.

A considerable amount of anxious negotiation had to be carried on with each authority in turn before the necessary consents were obtained. After all arrangements had been made and the system actually reconstructed for electric traction, an unusual obstacle arose. Kew Observatory had some magnetic recording instruments which might be affected by the proximity of electric current; and for eighteen months the new electric cars stood idle in the car depots while the Government and the company discussed the fate of these instruments. The affair was settled finally by the company going direct to the Treasury with an offer to compensate the Observatory, and to bear the cost of transferring the instruments to some desert spot where tramways would cease from troubling.

In April, 1901, the first sections were opened under electric traction, and since then the company has steadily pursued a policy of extension. At each few miles it has had to deal with a new local authority, and induce it to consent to tramways in its area, partly by means of money payments

or contributions to street widenings and other public improvements, partly by the solid argument that the company could give the district free intercommunication over an extensive system. If any of the local authorities had, as Kingston proposed to do, built a tramway system of its own, the cost of working that system as a separate unit would have been greater than when working it as part of a large undertaking; the difficulty of arranging through connection would have arisen, and the division of control would have told against the public pocket and convenience in other ways. Uniform control over a big inter-urban system means cheap through fares and uninterrupted services.

The districts of Shepherd's Bush, Hammersmith, Chiswick, Acton, Ealing, Southall, Brentford, Hounslow, Twickenham, Teddington, Richmond, Hampton, and Hampton Wick, are now linked up by electric tramways; and there are authorized extensions to Barnes, Mortlake, Kingston-on-Thames, Surbiton, Esher, the Dittons, Malden, Coombe, and Wimbledon. There is no saying where the company will stop in its effort to overrun the Thames valley. However, its progress has been temporarily arrested at some points by the opposition of the railway companies. Under the old Tramways Act, where promoters apply to the

Board of Trade for tramway Provisional Orders, the railway companies have no chance of opposing. The Act was framed in the horse days, when no one thought that tramways would ever poach on railway preserves. But in 1896 an Act called the Light Railways Act was passed, and it gave the railway companies a very powerful lever against tramway enterprise. It contained a clause which means in effect that where a railway company alleges unfair competition against a light railway scheme the Light Railway Commissioners are bound to reject the scheme, and to tell the promoters that they must bring it before Parliament in the form of a private Bill. The Act does not define a light railway, and it has been freely used to promote tramways running through several districts. The cheapness and simplicity of its procedure, combined with the fact that the consent of the local authorities is not a condition precedent to the hearing of the application (though it is usually necessary to its success), have led tramway promoters to prefer it to the Provisional Order method, or the expensive and tedious process of a private Bill.

The consideration given to railway opposition has (along with the consideration given to municipal opposition, in obedience to the veto principle of the Tramways Act, 1870) nullified to a great

extent the value of the Light Railways Act as a fillip to inter-urban tramway progress. It is almost impossible to extend a tramway system through a populous district without running parallel in some places to some existing steam railway lines. Now, the railway companies have long enjoyed the complete monopoly of inter-urban traffic, and they instinctively resent the intrusion of the electric tramcar. It is only natural that they should growl at a new means of transport which robs them of part of their short-distance traffic; it is only natural that they should spend thousands of pounds in trying to choke off electric tramway enterprise while it is young.

Nevertheless, the spirit of antagonism is weakening. The railway companies admit that their short-distance traffic pays them least of all. They make money easiest at the work they are best fitted for—carrying large numbers of passengers long distances at high speeds. They must admit that, with their fixed stations at wide intervals, their rigid time-tables, and their infrequent services, they have not the advantages of tramway companies which offer a five or ten minutes' service of cars, running along the roads, and stopping to set down and pick up passengers at any desired point. They must admit this, because it has been found invariably that where an electric tramway has

been built alongside a railway the amount of traffic which the railway has lost to the tramway has been a very small matter compared with the amount of new traffic which the tramway has created for itself.

If, therefore, questions of this kind are to be decided on the ground of public interest, the railways should not be allowed to throttle tramway development. Besides that, the tramway companies contend that, by encouraging land development and facilitating local traffic, they help to 'feed' the railways. A great deal might be said on this point to clinch the argument that tramways are really the friends and not the rivals of railways; but the necessity of a long argument is removed by the fact that the railway companies are beginning to see things in that light themselves. The Metropolitan District Railway, for instance, is now under the same control as the London United Tramways; the two undertakings are to be worked hand in hand even though they traverse in part the same districts. The idea underlying the co-operation is that the railways will carry the traffic at express speed to certain points, whence it will be distributed by the tramcars. Similarly, the Midland Railway Company has promoted a system of tramways which it had previously opposed successfully on the ground of competi-

tion; its intention is to work the railway in harmony with the tramways, each taking its special class of traffic. The London and North-Western Railway Company has arranged with the Dudley, Stourbridge, and District Electric Traction Company for special cars to collect traffic for long-distance excursions on its lines, even though the district traversed by the tramways is also partly served by railways.

A still more striking case is that of the North-Eastern Railway, which claims to have lost a great deal of its suburban traffic in the neighbourhood of Newcastle through tramway competition. Its Newcastle and district system is being 'electrified,' and the object of the railway in making the change is not to fight the electric tramways with electric railway traction, but to develop, by the aid of an improved electric-train service, comparatively long-distance season-ticket traffic between Newcastle and residential places like Whitley Bay —a class of traffic which the tramways do not attempt to carry, though they may help the railway company to increase it by 'feeding' the termini.

In course of time, therefore, the attitude of the railways towards tramways is likely to become more sober and friendly. We are likely to see more and more cases of tramway and railway

partnership such as the Metropolitan District and Midland Railway Companies have set up.

Not in all cases has the development of inter-urban tramways proceeded on such direct lines as that of the London United Tramway system. In the Black Country region it was not a matter of electrifying a single system and extending it into virgin country. When the British Electric Traction Company came on the scene there (about 1895) it found several tramway companies at work, some using horse traction, some using steam traction, with a variety of gauges, and with tenures and leases expiring at various intervals. The company set itself to make order out of this chaos. So complicated has the task proved that it is yet—after nearly eight years—not quite finished.

The first step was to acquire a controlling interest in the existing companies, and the second was to arrange fresh terms of tenure with a round score of local authorities. Either it was agreed to defer for twenty-one years or so the date of purchase, or a local authority decided to purchase the lines in its area, convert them to electric traction, and lease them for a period to the company. Bit by bit the lines were thus acquired, electrified, and brought under the uniform control of the company, with a uniform gauge and a uniform method of working. By this process of

consolidation, aided by various fresh extensions, an inter-urban tramway system extending from Birmingham in the east to Wolverhampton on the west and Kinver (in Worcestershire) on the south has been gradually built up.

The following are a few examples of the terms on which leases have been granted by the local authorities :

Document and Date.	Parties.	Term.	Rent.
LEASE, October 24, 1901.	Walsall Corporation and Lessee Co.	21 years from January 1, 1901.	£378 per annum.
		3 years from January 1, 1901.	£872 16s. 4d. per annum (including Burchills' Depot).
AGREEMENT, December 17, 1901.	Ditto	Until December 31, 1903.	£400 per annum.
AGREEMENT, December 31, 1900.	West Bromwich Corporation, B.E.T. Co., and Lessee Co.	21 years from completion of reconstruction.	$6\frac{1}{2}$ per cent. per annum on purchase-money on cost of works.
AGREEMENT, September 27, 1900.	Darlaston Urban District Council, the Tramways Co., and the Lessee Co.	Not purchasable till 1910, when purchaser to lease for 28 years, determinable by the Council at the end of 21 years.	$5\frac{1}{2}$ per cent. per annum on amount of purchase-money.
AGREEMENT, October 17, 1898.	Dudley Corporation and B.E.T. Co.	21 years from date of purchase. (Notice given 1903.)	To be settled by lay Arbitrator.
AGREEMENT, June 5, 1903.	Handsworth Urban District Council, Lessee Co., and B.E.T. Co.	Until June 30, 1911.	£65+$6\frac{1}{2}$ per cent. per annum on purchase-money and cost of electrical reconstruction and equipment.

Such a welding process is, of course, only possible where electric tramways under municipal control do not break into the scheme of consolidation. For instance, the towns of Wolverhampton and Birmingham form the east and west wings of the Black Country, and at Wolverhampton, there is a municipal tramway system, while in Birmingham the policy of municipalization has been adopted likewise. Where there is this duality of control, a certain special ingenuity has to be used to secure free interconnection between neighbouring districts, which comes as a matter of course when all the lines are under a single control. The case of Wolverhampton is complicated by the fact that a surface-contact system has been laid down there; the difference in system naturally increases the effect of the difference in control, and Wolverhampton has been isolated, in a tramway sense, from the Black Country system. At the time of writing, the artificial division line between the municipal and company lines has not been wiped out. As for Birmingham, the problem there is to secure free intercommunication between municipal lines within the city which are gradually being electrified and lines without the city, owned by the local authorities, and leased to the consolidating company. The situation is complicated; but eventually some mutual working arrangement

will doubtless be found through a policy of co-operation, so that the public will not suffer from the lack of through services.

The complications in the Black Country pale, however, before those in South Lancashire, where a most extensive system of inter-urban tramways is being built up. There the variety of control is so great as almost to baffle the attempt to give the tramway passengers unobstructed transit from town to town. If we take the region lying between Liverpool, Bolton, and Manchester, we find the tramway situation there to be like a Chinese puzzle. Liverpool has a fine municipal system of its own, running out a little into one or two neighbouring districts. Bolton also has a municipal system, and holds leases of lines in neighbouring districts. Between these two towns lie Wigan and St. Helens—Wigan with a municipal system branching out into surrounding districts, and St. Helens with a system belonging to the Corporation, and leased to the New St. Helens and District Tramways Company, Limited.

Like Liverpool, Manchester has a large municipal system within its own area, and it has succeeded in extending it into more than half a dozen surrounding districts, which have leased their lines to the Manchester Corporation. Salford, which is physically identical with Manchester,

has a separate municipal system; and after negotiations extending over three years, the two towns have arranged the terms of mutual running powers. Thus we have in this South Lancashire area a congeries of municipal systems, divided by blanks. The big cities have developed the urban and suburban services to a high degree, but they have not tackled the true problem of inter-urban communication—that is to say, the problem of linking up Salford and Bolton, Bolton and Wigan, Wigan and St. Helens, St. Helens and Liverpool. It is not to be expected that they should do so, because the concern of each local authority is with itself first, its immediate neighbours a long way second, and its distant neighbours a very long way third. Consequently, the development of town-to-town connections has been left to a company—the South Lancashire Tramways Company.

That company set itself to build the missing links between the towns. Already it has linked up Liverpool and Bolton through St. Helens. Its cars now run from St. Helens right into the heart of Liverpool. A novel arrangement has been made to secure this through service. At the boundary of the city, on the inward journey, the South Lancashire conductor gets off the car, and his place is taken by a Liverpool Corporation Tramway conductor. The car proceeds on its

journey through Liverpool, and all the receipts inside the boundary go to the Liverpool Corporation, which simply pays the South Lancashire Company a rent for the use of the car. While this arrangement does not secure through fares, it is a very simple and equitable way of securing continuous services. It is, perhaps, the best method of escape from the difficulties of making complicated agreements for running powers, division of profits, and so on.

As regards St. Helens, the company has been obliged to go to Parliament for compulsory running powers, after the manner of a railway; and Parliament has granted them, in spite of the opposition of the St. Helens Corporation. In this way the company, after securing the consents of the local authorities to its own links, is proceeding to burrow a continuous tramway route through the separate municipal systems. In such labours, we can well believe, nine-tenths of its energy is expended in diplomatic failures and conquests.

Many other examples could be given of complicated tramway situations—that, for instance, of the West Riding of Yorkshire, where there are four neighbouring municipal tramway systems, with four different gauges. But it is unnecessary to lay stress on that side of the picture. It is apparent that, since each local authority is a tram-

way autocrat, free to cook its tramway dish in its own particular way, every local boundary must threaten to prove a barrier to free intercommunication, an obstacle in the way of inter-urban tramway development. However, just as railway opposition to this development shows signs of slackening, so the tendency to aloofness on the part of individual local authorities shows signs of diminishing before a growing sense of the importance of securing continuous services of electric cars on all roads through populous districts. The instinctive jealousies of neighbouring local authorities (as witnessed by the long discussion between Manchester and Salford), and the antagonism of local authorities and companies differing on the question of municipal trading, are dissolving under the pressure of the public demand for the liberal growth of tramway facilities in all directions. Through the maze of apparent cross-purposes one sees an increasing desire to substitute co-operation for the traditional relationship of concealed or open unfriendliness.

Therefore, although one cannot deny the difficulties of the situation and its occasionally chaotic character, one must not be too pessimistic about the future. In spite of all obstacles inter-urban tramways *have* developed, and they are still developing. Much may be done by a simplifica-

tion of our tramway laws, allowing all tramway schemes to go before the Board of Trade, or some other permanent tribunal which will embody a definite principle of progress in the public interest, and possess sufficient power to enforce running powers and other means of securing through intercommunication where such are desirable. But much more may be done by spontaneously sinking local, political, and other differences—barriers none the less potent because they are invisible.

A word may be said in conclusion on the financial side of electric tramway development. Where tramways traverse busy, populous districts, or connect two such districts by lines of moderate length, a good steady business of a profitable kind is usually done. There are usually two periods of 'rush traffic' each working day—in the morning and evening—and on Saturdays and Sundays many lines enjoy a large amount of pleasure traffic. Bad weather and depression in trade are about the only things that seriously affect the average volume of traffic. Systems which serve holiday resorts suffer, of course, most severely from the first cause; a wet season may easily convert a good profit into a loss.

As a rule, a tramway becomes a solid revenue earner as soon as opened. People do not need to

be educated up to riding in tramcars, as they have to be educated up to adopting electric light. And the traffic is usually progressive, since transit facilities assist land development, and gradually encourage the practice of riding in tramcars until it becomes a habit. Nevertheless, the capital expenditure on an electric tramway system is really so heavy that a district must be fairly populous to support one. Careful discrimination is necessary, because the amount of possible traffic bears a close relation to the quantity and quality of the population. While tramway enterprise may be good business in London, Liverpool, Newcastle, or the Potteries, it may be anything but a gold-mine when sent to bless a region of deserted villages.

Electric-traction enterprise is not, however, being confined entirely to well populated regions. As we shall see in the next chapter, engineers have, in some cases, built what are called *tramroads* from town to town, across a fair stretch of almost open country. The advantages of this method will be discussed immediately. Another novel way of securing the advantages of electric traction cheaply is to be adopted in the Stroud and District Tramway system, authorized in the 1903 session. On one of the rural lines there, a service of 'railless trolley' cars is to be given. The cars take their

electric power from overhead wires in the usual way, but they run on ordinary wheels, and can be steered so as to dodge other traffic on the road. The whole cost of laying the rails is thus avoided, and the system can be installed at £1,000 per mile, as against the £7,000 of the ordinary electric tramcar system. Each car takes twice the amount of power to drive it which would be required if it ran on rails, but the great saving in capital expenditure is the main point where only a small volume of traffic is available. Should this plan succeed, it will probably be largely adopted as a means of opening up rural districts.

The carriage of parcels and goods on tramcars has not been carried on to any great extent in Britain; but one or two efforts in that direction are likely to be pioneers of a new branch (for Britain) of electric-traction enterprise. A concerted plan is being arranged for the collection and distribution of goods traffic over the South Lancashire lines. On the Potteries Electric Tramway system a large parcels service has been developed by the tramways. This class of business is common in America, and, although conditions are very different here, we may expect our tramway companies gradually to seek in the same direction a new source of usefulness and profit.

According to the latest available figures—which

are those published in the 1903 volume of the *Manual of Electrical Undertakings*—the amount of money spent by municipalities on electric tramways is £14,644,126. In 1900 the amount was £1,169,429. A similar progress is illustrated by the figures relating to electric-traction companies. In 1900 the total capital invested in these amounted to £19,639,530; now it is over £44,000,000. It is worth noting, too, that the average rate of dividend paid by sixty-four of the companies (those for which the figures were available) on the whole of their capital was last year 4·29 per cent. Lumping the good, bad, and indifferent together in this fashion shows that electric tramway business, as a whole, is no Klondyke. Individual companies vary greatly in the extent of their profits; but a moderate return on capital carefully invested is assured, and is to be preferred to sensational successes, alloyed by equally sensational failures.

The ordinary dividends of representative electric-traction companies for a period of three years are as follows:

Company.	Ordinary Dividends Per Cent.		
	1900.	1901.	1902.
Bristol Tramways and Carriage Co., Ltd.	8	8½	9
British Electric Traction Co., Ltd.	8	9	8
Cork Electric Tramways and Lighting Co., Ltd.	5	5	5½
Dublin United Tramways Co., Ltd.	7	5	5½
Dudley, Stourbridge, and District Electric Traction Co., Ltd. ...	4	4½	4½
Imperial Tramways Co., Ltd. ...	8	10	£5 10s. per £10 share.
London United Tramways (1901), Ltd.	—	—	8
Oldham, Ashton, and Hyde Electric Tramway Co., Ltd.	6	8	8
Poole and District Electric Traction Co., Ltd.	—	6	8
Potteries Electric Traction Co., Ltd.	2	4	5
Tynemouth and District Electric Traction Co., Ltd.	—	7	7½

CHAPTER VIII

ELECTRIC RAILWAYS

THE chapter before last showed us that (if a double 'bull' may be allowed) the first electric tramways were railways, and the first English electric railways were built in Ireland. After the pioneer railways were built at Giant's Causeway and Bessbrook, there was, however, a long interval of almost complete inaction as regards electric railways. These were engineering experiments, and the time was hardly ripe for the application of electric power to railways in any general way. Even yet the electric railway is only in its infancy. Beyond the 'tube' railways of London, the chronicler of progress in this department has to speak mainly in the future tense.

The Giant's Causeway and the Bessbrook railways used electricity generated by water power. As waterfalls of any magnitude are not common

in the British Isles, there were not many places where a similar plan could be adopted. Engineers had therefore to depend for the most part upon steam power; and it was some time before they could prove that electricity so generated could be economically used in the handling of ordinary railway traffic. Tramways did not afford quite a parallel case, since the running of single cars at comparatively slow speeds, and with frequent stoppages, is not the sort of thing that is wanted on the ordinary railway. Hence we need not wonder that it is to very special circumstances we owe the earliest use of electric power on railway systems of any magnitude or importance.

In the case of the Liverpool Overhead Railway, for instance, electricity was used because there were many disadvantages attached to the use of steam on lines carried by girders over public streets. That line was authorized in 1888, and started working in 1893; its primary object was to carry the dock passenger traffic free of the goods traffic. Likewise the pioneer tube railway—the City and South London Railway, opened in 1890—was electrically operated because steam was out of the question in deep-level tunnels. In the Metropolitan Railway, where the tunnel is built close to the surface, with frequent wide openings for ventilation, the atmospheric conditions are

rendered quite bad enough with the smoke, steam, and sulphur fumes from the locomotives. It is related that one of the directors of that railway considered the 'undergound' as the healthiest place in London, owing to the antiseptic properties of the sulphur fumes. If a similar mode of working had been adopted on the City and South London, this enthusiast would have been sterilized and embalmed to his complete satisfaction.

Necessity, therefore, was the father and the mother of the invention of electric railways in this country. In another form, as we shall see, it has been the tutor of their progress. The pioneer railways were successful in proving that large bodies of traffic could be economically handled by electric power. The same causes that made the electric tramway more economical than the horse or steam tramway made the electric railway more economical than the steam railway. One result of the City and South London enterprise was to prove the feasibility of deep-level tubes, but another and even more widely important result was to point a new way of salvation for railway companies suffering from the sin or the misfortune of heavy working expenses. For one or another cause, many railways have shown a slow but certain increase in the critical percentage of working expenses to receipts. Their gross receipts might show an upward tendency,

but they had to spend more and more to earn them; and with increasing rates and taxes, and increasing burdens put upon them in the way of cheap workmen's trains, and so on, they have been forced to cast about anxiously for some way of easing the burden of expense. In some instances their anxiety has been quickened by the loss of some of their short-distance suburban and inter-urban traffic through electric tramway development.

Naturally enough, the first steam railway to take the electric cure was the railway which suffered most from financial debility. The Mersey Railway Company was, in fact, in the hands of a receiver when arrangements were made to electrify it. The peculiar character of the railway made the cost of working it particularly heavy, and it illustrates the economy of electrical operation with peculiar emphasis. It consists for the most part of a tunnel dug under the Mersey. The gradients on both sides of the river are very heavy, and locomotives of unusual weight and power had to be used. The water from the river and its banks oozed continually into the tunnel, necessitating almost ceaseless pumping. The smoke and fumes from the engines made travelling disagreeable, in spite of costly efforts in the way of ventilation. All these disadvantages combined to make the

percentage of working expenses to receipts so high that the company could not even meet its debenture obligations.

Now that the railway is worked by electricity (the change was completed in May, 1903) all the underground pumping and ventilation is done by electric power more cheaply and easily than it used to be done with steam power. In the actual working of the trains no less than a revolution has been effected. Locomotives of any kind have vanished, and it would puzzle a lay observer to discover where the driving mechanism is placed on the new electric trains. He would probably echo the Chinaman's expression of wonder when he first saw an electric car: 'No pushee, no pullee; no smokee, no smellee—go like hellee!' The trains are equipped on what is known as the 'multiple-unit' system, where, instead of having a single driving 'unit' like a locomotive, electric motors are placed on the first, middle, and last cars of the train, and controlled from a small 'cab' at either end of the train. The advantages of this arrangement are that the weight of the train is more evenly distributed, and that the power required for hauling is economized. The track-pounding locomotive (which must be heavy enough to grip the rails well and powerful enough to haul itself and the heaviest train up the steepest

AN ELECTRIC TRAIN ON THE METROPOLITAN DISTRICT RAILWAY (EALING AND SOUTH HARROW SECTION)

Equipped on the multiple-unit system by the British Thomson-Houston Company, Limited

gradient at the highest speed) is more wasteful of power than an arrangement which carries no unnecessary weight, and is fed with energy from a central power station to the amount required at each particular moment. A more rapid rate of acceleration is also obtained, so that less time is wasted in stopping and starting. Shunting at termini is avoided, since all that the driver has to do when arriving at a terminus is to walk through the train and take up his station in the cab at the other end, where the controlling apparatus is also situated. Trains can be made up readily to any size to suit the variations in traffic simply by attaching or removing 'trailer' cars to those fitted with motors. And whatever the length of the train, the power used to drive it is proportional to its size and the burden of traffic it carries. This gives great elasticity in the handling of traffic, and great economy also.

The stern necessity which drove the Mersey Railway to drown its sorrows in electricity was mitigated in the case of the first London railway to decide upon the same policy—the Metropolitan District Railway. During a long and dismal career that company never once paid a dividend on its ordinary shares; and its directors are now looking to electric traction to increase the company's gross receipts and diminish the ratio of

working expenses. The Metropolitan Railway, which has the District as a partner on the Inner Circle, was not so hard pressed financially, but it is making the same change with a similar hope. Thus the two main city and suburban systems in London are in process of conversion.

The case of the District is especially interesting. Its system, and the London United Tramways, the Baker Street and Waterloo Railway, the Great Northern, Piccadilly, and Brompton Railway, and the Charing Cross, Euston, and Hampstead Railway ('tubes' in course of construction), are all to be combined under a single control, represented by Mr. C. T. Yerkes, of Chicago, and his financial friends on both sides of the Atlantic. The congeries of lines will be fed with electric power from a huge station now being built at Chelsea; through (and perhaps zone or uniform 2d.) fares, free intercommunication, and so on, will be the order of the day. According to one's personal point of view, this consolidation represents a wicked monopoly, or an organized effort to find a comprehensive solution to the traffic problem of London. At the present stage it is, perhaps, premature to dogmatize one way or the other; but in a general way the unity of control should bring about economy in working and administration, along with additional convenience to the travelling public.

Beyond the 'tube' railways and the two other railways mentioned, London railways remain for the present faithful to steam. We say 'for the present,' because the Great Eastern Railway, the London, Chatham, and Dover Railway, the London, Tilbury, and Southend Railway, and the London, Brighton, and South Coast Railway, have all obtained powers which will enable them to electrify as soon as the spirit moves them and their finances will allow. Being railway companies, and British into the bargain, they move with caution.

Outside London the same diffidence about taking the plunge is not so general, and in the Newcastle district we have what is in some ways the most ambitious attempt to apply electric traction to a full-sized railway. Some thirty-seven miles of double, single, and four line track on the North-Eastern Railway are being reconstructed for electric traction, and eventually both the goods and the passenger traffic will be hauled by electric power. The Liverpool to Southport section of the Lancashire and Yorkshire Company's system (hitherto known as the Languishing and Yawning) has carried out the same change. If these two experiments, in combination with the Metropolitan and Metropolitan District enterprises, prove a success—which is morally certain—we

may look to see all similar railway systems electrified as fast as possible.

The phrase 'all similar railway systems' does not, of course, include such lines as the London and North-Western main line to Carlisle, or the Great Northern main line to York. Such lines, with their long distances, extra high speeds, and immense volume of miscellaneous traffic, present a different problem to the electrical engineer than a railway like the Metropolitan District. The method of electrical distribution employed there is like that used on a tramway: the moving train takes its current direct at 500 volts from a 'third rail' laid between or alongside the others, just as a tramway takes current from the overhead or underground conductors. But engineers are looking for some other method more suited to the conditions of a great main line system. All sorts of different solutions are propounded, but the tendency seems to be towards utilizing high-tension currents in the motors themselves. This is one of the undecided questions in electric traction. It may be settled early or it may be settled late, though it seems certain that ultimately the beneficial change which has taken place on tramways and certain railways will be extended also to the great trunk systems where the steam locomotive is at present supreme.

The Liverpool Overhead Railway is at present the only sample of its kind in this country, but an attempt may soon be made to introduce (in London) another form of overhead railway which has been in operation on the Continent. The Barmen-Elberfeld Railway in Germany was constructed by the Schuckert Company on the 'suspended' system. There is only one rail, supported in mid air, as it were, by steel girders, and the cars hang from this rail and are propelled by electric power. The appearance of the steel structure has earned for it the name of the 'engineering spider.' Very little ground space is occupied by this form of railway, which passes over streets, rivers, canals, and low houses, without causing any serious obstruction or involving expensive engineering complications. These advantages are clearly of great importance where there is a question of opening up new avenues of transport in a crowded city like London.

A word must be said here regarding the Behr mono-railway which has been authorized between Liverpool and Manchester. This railway may be taken as an embodiment of the political principle that safety lies in sitting on the fence. A speed of 110 miles per hour is expected to be reached without risk of derailment with single cars, propelled by electric power and balanced on a single

rail, somewhat after the manner of the steam mono-railway at Ballybunion. The construction of this novel electric railway is awaited with a good deal of interest, to say nothing of scepticism. Should it prove successful, a new era in rapid inter-urban traffic will be undoubtedly opened.

Between the electric tramway proper and the railway proper lies the 'light railway.' Many tramways, as we have seen, have been promoted as light railways; only a minority of miles have, however, been constructed really as light railways. Nevertheless, within recent times, several companies have preferred this mode of construction. Instead of keeping to the roads, they have purchased a right of way of their own, and constructed thereon what is practically an ordinary railway, save that the mode of construction is less ponderous. The rails are built to carry tramcars (usually single-deckers), and the overhead construction is closely similar to that of the usual tramway. Near Newcastle, at Kinver (near Dudley), at Portsdown (near Portsmouth), at Chatham, Fleetwood, and elsewhere, 'tramroads' of this kind have been or are being made. They have the advantage of being free of the road traffic, and free also of the restrictions and obligations attached to laying rails on roads. Higher speeds can be reached with

safety, and the engineers are free to work the service in the best way.

The one drawback is the cost of land. It is seldom easy to buy a suitable strip of ground at a low price, since the law puts such enterprises on the same footing as heavy railways, making it necessary for the promoters, when granted powers of compulsory purchase, to buy the whole of a man's plot of ground when they want only a corner of it. However, lines of this kind are certain to grow in favour for inter-urban service. They are very common and popular in America and on the Continent. Unhappily, in this free country we have a plethora of vested interests, and the path of the tramroad promoter is not much less thorny than that of the tramway pioneer.

Apart from 'tubes,' figures as to the financial results of electric traction on railways are, of course, not yet available in any volume. And in the case of tubes the peculiarities of construction and working make any prophecies therefrom to the case of ordinary railways quite useless. The Central London Railway (the 'Twopenny Tube'), for instance, cost the enormous sum of about half a million a mile to build; and its percentage of working expenses (amounting to 53 per cent. for the first half of 1903) is heightened by the cost of working the lifts which convey passengers from

the surface to the station platforms and *vice versâ*. However, the Central London Railway earns 4 per cent. on the whole of its capital, and the return earned by the City and South London Railway is about the same, with a working percentage of 44 per cent. The Waterloo and City Railway, which is a short 'tube' connecting Waterloo Station with the Bank, earns now $3\frac{1}{4}$ per cent. per annum. These are not sumptuous earnings, and they show that digging tubes in London clay is not the same as digging for gold. Nevertheless, the margin of profit is fair as railway finance goes nowadays, and it is sufficient to induce an almost embarrassing number of 'tube' promotions to make their appearance.

The comparatively low percentage of costs is, however, the main point for the ordinary railway director. His capital burdens are not so heavy as those of a tube, even if we count in the additional cost of electrical conversion. Hence he expects to earn a better return than the tube if he win anything like the same amount of traffic. His hopes in that direction depend altogether upon circumstances, but he has generally good reason to hope that electricity will bring him new traffic, as well as reduce his almost overwhelming working expenses.

CHAPTER IX

ELECTRIC POWER: AN INDUSTRIAL REVOLUTION

IT is related that James Watt, when offering a model of his steam-engine to the King, made the following speech: 'I present to your Majesty that which all Kings most desire—Power.' The late Sir F. Bramwell recalled this picturesque anecdote when laying the foundation-stone of the first great electric power station at Pontypridd in 1902—about one hundred years after the appearance of the steam-engine. The reminiscence on that occasion helped to emphasize the fact that *power* is the supreme gift of electricity to mankind.

The electric tramway and railway are familiar examples of the practical application of electric power, but the revolution which is being brought about by their aid is, after all, a very secondary affair compared with the revolution to which the industrial use of electric power is giving birth.

If we cast a rapid eye over the progress of the human race, we see that each great stage is marked by the conquest of some new source of power. The first step was the use of implements by which man extended the simple power of his head and hands. Then, with his superior moral strength, he tamed the reindeer, the ox, and the horse, using their greater brute strength in the hunt, in war, in transport, in agriculture. For countless centuries these were his only aids, until he learned to direct the forces of the wind and running water. After water-mills and windmills came the steam-engine, a servant of far greater strength and far more docile. There is hardly a single phase of nineteenth-century life but bears the impress of that great source of power; it re-created old industries, brought forth a thousand new ones. Commerce, politics, art, science, literature, and social life were transformed through the simple fact that man had tapped a new reservoir of energy, which he could call into action and control with a turn of his wrist.

It is almost a truism now that steam has altered the face of the world beyond recognition. Some people will assert, too, that steam has blackened it beyond repair. Part of this complaint is mere sentiment, though no one will deny that the glories of the steam age have their ugly side. That side

might be ignored here, were it not for the happy fact that the latest discovery in the realm of power promises a new age in which the glories of the steam age will be heightened and its drawbacks to a great degree removed. Nowadays the language of enthusiasm is unpopular, but if one admits that the birth of steam power marked a new era in human progress, one cannot deny that electric power may also mark a new era, and one in which the miseries of the old will be transformed out of existence.

It is, in fact, in the blackness of the steam age that we see best the brightness of the coming electrical age. How steam brought trouble in its train may be very simply told. In the eighteenth century, when animal and water power were in use, industries were conducted on the small scale. Mills were scattered down the valleys at points where the streams could be dammed back; agriculture was in a thriving condition, maintaining a sturdy population on innumerable farms. The largest towns then were market towns, to which the produce of the surrounding country was brought for sale. Thus the conditions of life tended to segregation, to the multiplication of small farms, small mills, and small towns.

The coming of the steam-engine, accompanied by the discovery of immense coal and iron

deposits, changed all that. Steam could do the work of a dozen, a hundred, water-wheels; and accordingly steam factories were built of a size previously unknown. The productive capacities of a hundred scattered water-mills were concentrated under a single roof. Naturally, the new factories were built close to the coal and iron fields, preferably in the neighbourhood of canals, for the ready conveyance of goods, with the result that numerous factories sprang up close together in a limited number of favoured localities. And round each factory or group of factories rose the homes of the thousands of hands employed in the new industries. Money was made quickly in those days, and in the rush for wealth neither master nor man took thought of the amenities of existence. In smoke and filth and ugliness grew up the characteristic child of the steam age—the British manufacturing town.

The railways might have been expected to relieve some of the congestion so caused, though they appeared really to encourage the growth of large and overcrowded towns. The aggregation of huge factories close to the iron and coal centres seemed an imperative necessity. At any rate, the small isolated mill became a thing of the past. Production on a large scale in a single factory was far cheaper than production in a number of

small scattered buildings; the steam-driven mill effectually killed the old water-mill. With the prospect of high wages, the tide of humanity set in from the healthy country to the unhealthy towns, and in an incredibly short time the social reformer was face to face with a duplex problem: the depopulated country and the over-populated town.

That problem has now become very complicated, and numerous remedies have been proposed or embodied in Acts of Parliament. It is interesting, and perhaps a little pathetic, to think that the hydra-headed trouble has arisen from a single characteristic of steam power. To be economically used, steam power must be used where it is generated; the engine must act directly on the machinery it is meant to drive. There is a great loss in transmitting the power over distances of a few dozen yards, either in the form of steam under pressure in pipes, or by the use of belts and shafting. In other words it is commercially impossible to *transmit* steam power to a distance. If we want to use steam power away from the source of coal-supply, we must cart the coals to the desired point, and that adds considerably to the cost of the power when produced. Therefore it was for cheapness and not for company that the steam-driven factories

huddled themselves together near the sources of cheap coal.

On the other hand, the great excellence of electric power lies in the fact that it may be transmitted without serious loss over long distances. It has other excellencies but this is the chief. At the Niagara Falls electric power is generated by turbine-driven dynamos, and transmitted at high pressure on overhead wires to Buffalo, twenty-seven miles distant, where it is 'transformed' down to a lower pressure, and used for working machinery in factories and for lighting. Such a typical case of long-distance transmission of electricity serves to show how radically different a thing electric power is from steam power, and how much more may be done with it. If you use electric power you are not compelled to place your factory at the point where coal is cheapest and may be most suitably used; you are at liberty to go further afield, planting your factory on an open site, and feeding it with power conveyed from a distant source.

It is easy to see that if electricity had made its appearance in its present commercial form at the beginning of the age of factories, the congested manufacturing town would not have been a necessity. The tendency to aggregation would have been opposed by the centrifugal force of a

means of conveying power cheaply to any desired point. Big factories there would have been, of course, for that way cheapness lies; but the aggregation of big factories into crowded industrial settlements (the root of the mischief) would have been avoided. However, it is no use crying over spilt milk. We have got our ugly, overgrown, overcrowded, and filthy manufacturing towns, and the one practical question is, how far they are likely to be altered by the substitution of electric for steam power As a corollary, we have the question whether the development of electric power is likely to stem the living tides which are still flowing towards the larger towns, leaving the country barren and depopulated.

By a natural reaction the overcrowded town is mending itself. It is something like a planet which, grown too great for consistent strength, flings off satellites from its superfluous mass. In order to escape the ever-growing burden of heavy rates and taxes, in order to get cheap land, and in order to house workpeople in healthy surroundings, old factories are being moved from crowded city centres to open sites. New factories are likewise erected, not in the midst of houses, but among the fields. Proximity to a canal or railway keeps the manufacturer in touch with sources of supply; and if he is within reasonable distance of a town

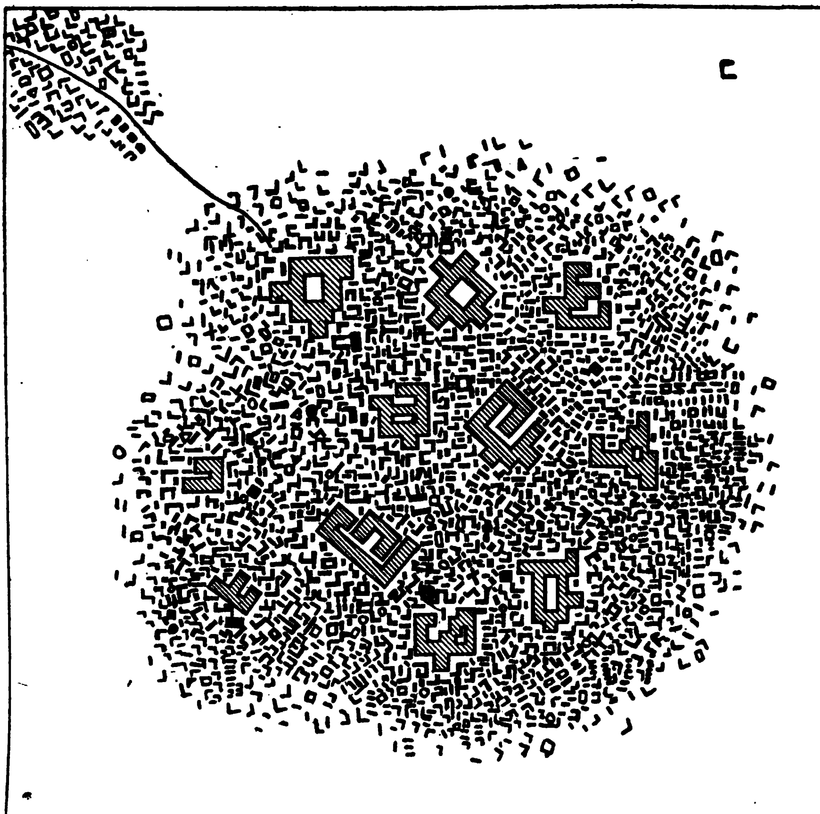
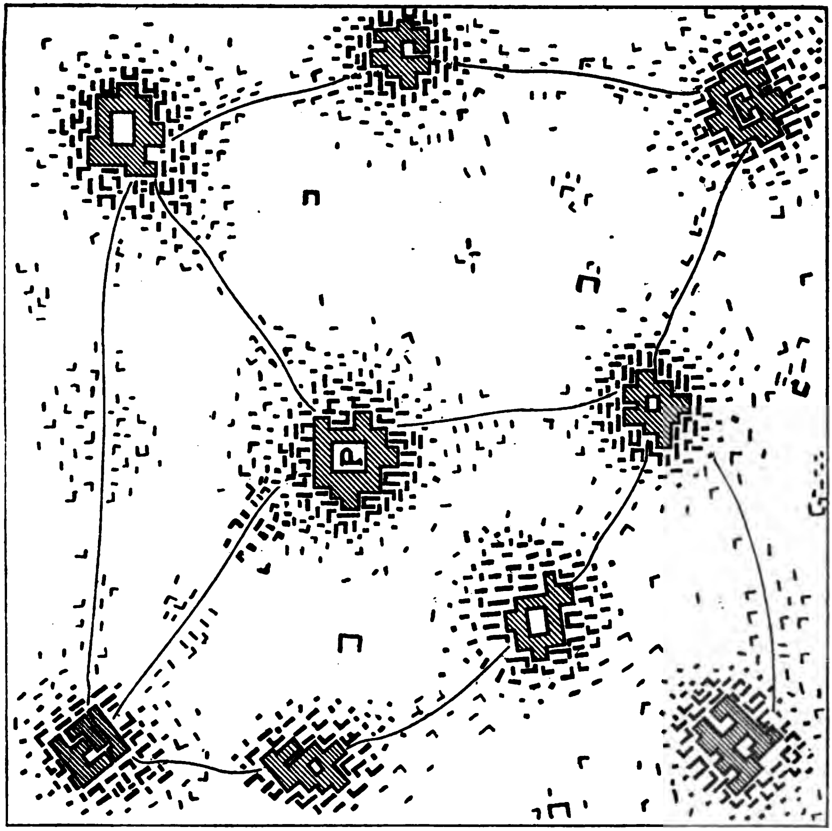


FIG. 2. — The left-hand diagram represents a typical manufacturing town settlement under a system of distribution



of the steam age. The right-hand diagram represents a typical industrial
of cheap electric power. (See p. 124)

he will find the sources of labour open to his command. In this way the decentralization of industries, as it might be called, is already taking place, like the backward swing of a pendulum. The General Electric Company has erected new works at Witton, near Birmingham; the British Westinghouse Company has settled at Trafford Park, near Manchester; Crompton and Company manufacture dynamos in works outside Chelmsford; the British Thomson-Houston Company has settled near Rugby, and the Brush Electrical Engineering Company at Loughborough. These are a few cases drawn from the electrical industry alone. Many other examples might be given, but even at the best the migration back to the land has been fitful, irregular. It has lacked a definite impulse, and the manufacturer has always felt a certain diffidence in moving away from the teeming industrial centre.

Probably that impulse will come when cheap power is added to the attractions of cheap land, cheap labour, low rates and taxes, and freedom from Building Acts, which prevent (as in London) the erection of a factory on a proper modern scale. It is the claim of the various electric-power distribution enterprises now on foot that they will be able to supply power at practically any desired point over a wide area cheaper than a manu-

facturer can himself produce it. How that claim may be upheld we shall see presently; but if we assume that progress in electric-power distribution will enable a manufacturer to obtain cheap power at almost any spot he likes to select, we perceive at once that the range of possible factory sites is immensely widened—widened, in fact, more than in the days of scattered water-mills, before congestion was thought about. The development of electric light railways and other means of transport will be accelerated by the same cause, and in the course of time fewer and fewer districts will be isolated, either in the industrial or the social sense.

It is possible, perhaps, to exaggerate the importance of cheap power to the manufacturer, since cheap power is only one of the elements of success in the industrial struggle. But it is a prime element, as every manufacturer will admit. The manufacturer's ideal is the cheapest mode of production, and he can get that only by a combination of the factors of economy. He must be allowed to build his factory in such a way that he can handle his goods in course of manufacture with the smallest waste of time, trouble, and power. He cannot always do that in a town, where there are restrictions as to the height or capacity of single buildings. He must have plenty

of cheap land, with an ample supply of cheap water and facilities for canal and railway transit. He cannot always find these readily in a crowded industrial centre. He must be free from the menace of complaints from neighbours on the score of nuisance. In a town a factory is always apt to get into trouble on that score. He must not be burdened with heavy rates and taxes. We hear nothing but complaints (in a very minor key and *crescendo*) on that ground from industrial concerns situated in large towns. He must have cheap labour. The cost of labour is ruled by the cost of living, which is greater in cities than in small towns. Finally, he must have cheap power to work his machinery. With electric-power distribution on the system now contemplated, power will be obtainable cheaper outside than inside a large city.

In this way electricity may afford the final argument for the decentralization of industries, for the redistribution of factories in a manner which will make congestion impossible. The diagrams on pp. 120, 121 illustrate in a crude but graphic way the meaning and the effect of this decentralization. On the one hand, there is a typical manufacturing town of the steam age, overgrown, crowded, congested, like a crowd of iron filings round a single magnetic centre. On

the other hand, there is a district, containing about the same number of factories and inhabitants, with the factories distributed as they would be under a system of electric-power distribution. Here the magnetic centres are scattered; the population has ample room to dispose itself in a healthy manner; and the isolation of each centre is prevented by the extension of electric tramways and railways. When we add the fact that the use of electric power involves no smoke or filth of any kind, the conditions of existence in this prophetic land appear Utopian compared with those in the bad old days of the reign of steam.

To heighten the bright side of the prospect (we doubt whether it has a dark side at all), the effect of this industrial redistribution on rural industries may be mentioned. As things are, we know that many rural districts, where dairy produce, fruit, and vegetables might be obtained in abundance, are more remote, economically speaking, from our great cities and other centres of demand than Denmark or Normandy; that is to say, Denmark gets its hens and its eggs and Normandy its butter cheaper to the English markets than the English farmer can. Various causes may be blamed for this, but it is clear that the redistribution of population illustrated in the second diagram will, with the growth of electric transport, place

the rural districts in close touch with several immediate markets on all sides. It would be surprising if, under such conditions, a great stimulus were not given to rural industries which are now declining. This is no mere fanciful forecast, since in Belgium the free development of light railways (under much happier conditions than those prevalent here) has been the direct cause of reviving and creating industries in previously isolated and vacant rural areas.

This revival of rural enterprise will, in combination with the decentralization of industries, surely tend to reverse the tide which during the steam age left the country high and dry and flooded the towns to overflowing. Sociologists have remarked how apt the course of human affairs is to move rhythmically, in strophe and antistrophe, in action and reaction. Here, in electric power, we have the hope of a reversal of a process which seems at times to have brought more misery and ugliness into our life than it did prosperity. Electricity may yet remodel both town and country, giving us, in place of sweltering, smoke-ridden towns, industrial settlements with ample breathing-room, and, in place of a deserted country, a rural world made busy with ever-increasing demands on its resources.

We do not assert that electricity alone will do

these things, because in economic changes no one factor is almighty. But electricity may, as we have before hinted, bring as much change into the conditions of existence as steam did—and probably much more. The chances clearly are that it will reorganize these conditions for good and not for ill; and here we see that the work of the electrical engineer has a greatness which transcends its merely commercial importance. We see that the mission of the electrical engineer will not be completed for many a long year to come, that the field of his labours is an ever-widening one, with a promise of progressive usefulness. There is a certain moral satisfaction in this which will please some minds not keen to see a spiritual element in what is apparently a mere matter of mechanics. Other minds will find in it a reassurance that the business of electric-power distribution has a grand future.

CHAPTER X

THE ECONOMIES OF ELECTRIC POWER

TURNING from these general matters, we have to consider the particular claims of electric power to supersede steam. A manufacturer cannot be expected to substitute electric for steam driving in his factory unless the change means a real saving of money; the revolution which is foreshadowed in the previous chapter would only be a paper revolution if electric power did not meet the ultimate test in commercial competition—the test of £ s. d. It meets that test successfully in a double fashion—first, by promising economies in use and distribution throughout a single factory; and second, by promising economies in first cost when supplied on a plan hereafter to be described.

Although the use of electricity for working machinery is to most people rather a novelty, it

is, in fact, as old a story as electric light itself. As far back as 1879, Sir William Armstrong (as he then was) had, at his house at Craigside, a water-power installation which gave electricity for lighting his library during the evening and for working light tools, such as lathes and sawing-machines, during the daytime. This was a modest beginning, but it foreshadowed what would happen when electrical installations grew in size and gave the engineer an almost unlimited supply of power.

For a time, nevertheless, it was not easy to convince people that any economy would result from the use of steam-generated electricity in factories. Some 'experts' bluntly asserted that any economy was impossible. They said: 'Here you have a steam-engine driving the machinery directly through belts and shafting; now you want to harness that same engine to a dynamo, carry the electric currents so generated through wires to the various tools in your factory and make the current work electric motors attached to these tools. That is to say, in place of the direct application of the power of the steam-engine, you transform that power into electrical energy by means of the dynamo, and back again into mechanical energy by means of the motors; and in each of these transformations there is inevitably a loss of

energy. How have you the audacity to claim economy for that roundabout method of working your machinery?'

This imaginary expert is all right as far as he goes, but he does not go far enough. There is undoubtedly a loss incurred in the two transformations; but as dynamos and motors are extremely efficient machines, the loss of energy is much less than one might suppose. It is certainly much less —and this is a crucial point—than the loss of energy in belting and shafting. Sometimes as much as half the power of a factory engine will be lost before it gets to the machines themselves—wasted in the long lines of heavy shafts and the numerous whirling belts. If the power be distributed electrically, no belts or shafts are necessary, since the motors may be fixed direct on to the machine to be worked. Therein lies a great saving of power, and it is increased by another advantage of the electric-power system. In a steam-driven factory the heavy shafts have to be kept continually running whether the whole, half, third, or none at all of the machines are actually at work. With electric power the operator can switch on the current for each machine as and when required, so that when the machine is out of work there is no waste of power. With machines which are worked intermittently, such as lifts,

cranes, printing-presses, and so on, the saving from this cause is very great.

The upshot is that, in spite of the double transformation of energy which electric driving involves, it is much cheaper in action than steam driving through belts and shafts. Engineers find, too, that with the electric system they can calculate accurately the power needed for each machine, so that the total horse-power required may be estimated and any excess of capacity in the power installation avoided. These various points of advantage are now fully appreciated by manufacturers, and we find many of them going to the expense of electrical plant and equipment in their works, in order to enjoy the economy, convenience, and cleanliness of electric power. In the case of the Barrow works of Messrs. Vickers, Sons, and Maxim, Limited, it was found that the substitution of electric for steam driving saved half the coal bill, with an increase of over 50 per cent. in output.

It may be added that in coal-mines, quarries, brickfields, shipyards, and other places where power is required at a number of isolated and sometimes awkward points over a wide area, the advantages of electric-power distribution are most conspicuous. Wherever a flexible cable may be carried, there power may be applied without

appreciable loss. It is a very different matter in mines where (with steam power) engines have to be placed underground, and steam conveyed for hundreds of yards in leaky pipes; there the waste is positively sinful.

However, electric power does not plead for acceptance simply on the score of economy in distribution through a factory or mine. When generated under certain conditions, it claims cheapness in prime cost compared with the cost of power to the average factory. How that comes about may be best understood by going back on our steps a little way, and taking up the trail again with electric lighting and electric tramway schemes.

Most of the large municipal tramway systems (in Manchester, Bradford, Liverpool, and so on) take power from the same electric generating station which supplies the lighting demand in the city. Likewise, companies try wherever they can to combine lighting and traction schemes in one. They do this partly because it is on the face of it cheaper to have one site, one building, one set of boilers, one electric generator, one chimney, one engineer, one staff, one power-producing business, than two sites, two buildings, two sets of boilers, two electric generators, two chimneys, two engineers, two staffs, two independent power-

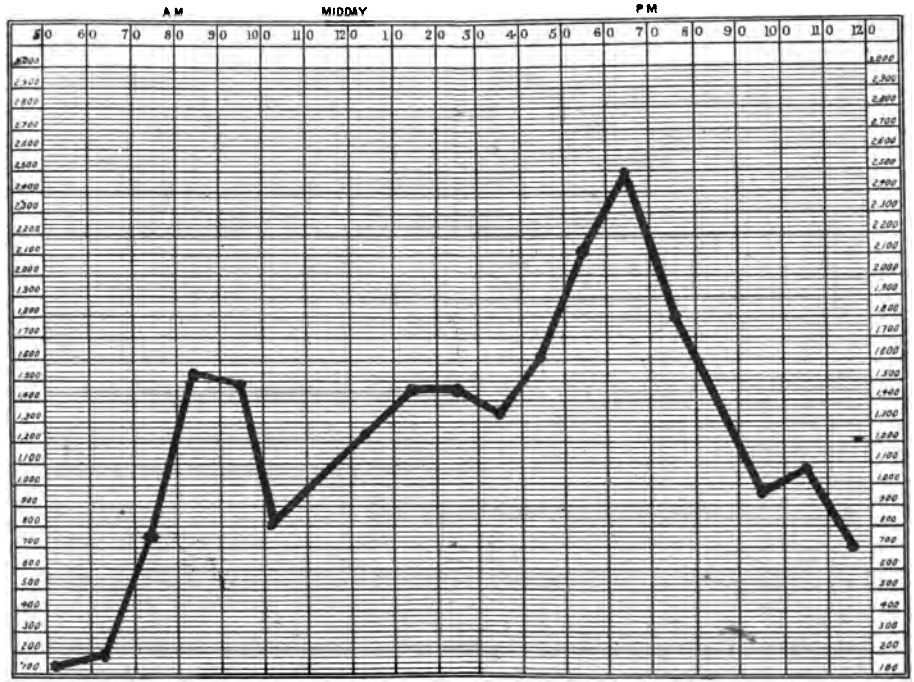


FIG. 3.—Showing the variations of the tramway traffic during a single day on an urban tramway. (From the report on the Liverpool Corporation Tramways, 1903.)

producing businesses. And it is cheaper, even though the capacity of the combined station had to be equal to the combined capacities of the two separate stations. At first sight one would think the capacities ought to bear that relation, but, as a matter of fact, the capacity of a combined lighting and traction station may be less than the added capacities of two isolated stations doing the same work.

The explanation of this apparent paradox is simple enough. Taking the lighting business first, we have found (see p. 59) that the demand for light in an ordinary town is limited to a few hours in the evening—from sundown to bedtime, in fact. At other times the demand for light may be next to nothing, being for cellars, basements, and other badly-lighted rooms. Unless the use of electricity for cooking and heating or for electric fans be encouraged, the generating machinery lies practically idle for twenty hours out of the twenty-four. The state of affairs may be compared to a church maintaining at a high salary a parson who preaches once on Sunday, and does no parochial work during the week.

Taking the tramway business next, we find a very different state of affairs. The demand starts at an early hour in the morning, reaches a 'peak'

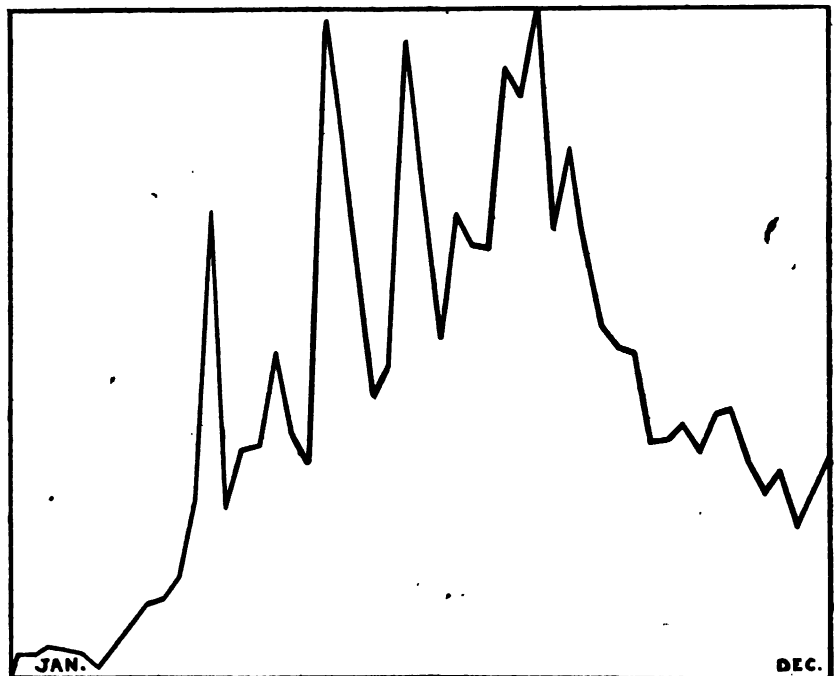


FIG. 4.—Showing the annual course of tramway traffic in a town similar in character to the one whose electric lighting load for the same period is represented in Fig. 5.

at the rush to business round about nine and ten o'clock, falls away till another moderate spurt occurs at the dinner-hour, and rises to another peak at the hours of the rush home from office or factory. Then it falls away till it reaches zero after the last car has conveyed the reveller home (see Fig. 3). If now we put the two demands together, we find that the peak of the lighting load comes after the evening peak of the traction load. In practice it seldom happens (especially in summer) that the maximum tramway traffic and the maximum lighting demand occur simultaneously. The lighting load, in fact, helps to sustain the falling tramway load in the evening, and to give the generating machinery the comfort of a run at a fairly even pace for several hours on end. Further, if we take the whole year round, we find that while the lighting demand decreases in summer, the traction demand increases (see Figs. 4 and 5). Because the two demands dovetail into each other in this way, the machinery at the power station has not to be built up to the capacity which would be necessary if the full lighting demand came right on the top of the full traction demand.

The combining of lighting and traction is the electrical engineer's first step towards what he calls a good 'diversity factor.' Mr. B. Alfred

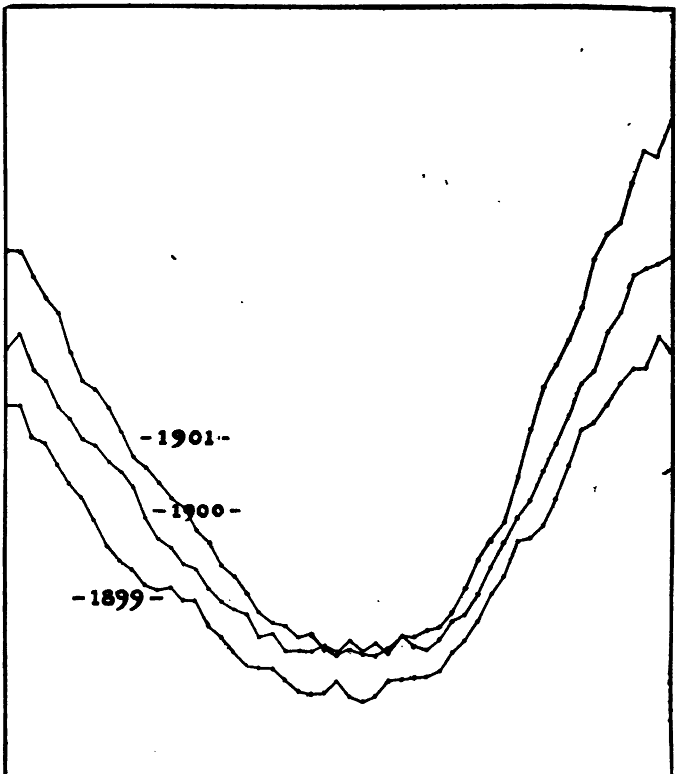


FIG. 5.—These curves represent the course of the demand on a typical electric-lighting station from January to December.

Raworth* has illustrated the meaning of this term by a reference to the famous Mrs. Bouncer,

* In an admirable article on 'The Electric Distribution of Power,' published in *Traction and Transmission*, July, 1901.

who 'got a diversity factor by letting her room to Box and Cox, one of whom occupied it in the daytime and the other at night. She got two rents for a single plant and a load factor of nearly 100 per cent.' The electrical engineer goes as far as he can towards the attainment of this ideal by adding another type of demand to those of lighting and traction. He seeks to supply electricity, not only for tramways and lighting, but for industrial power purposes also.

Let us suppose that he adds to his list of customers several large factories in a town. There, again, we find that he will not need to add to his power station the full capacity required for his factory-power load. The same sort of dovetailing takes place again, because the rush on the tramways occurs at precisely the times when the factories are about to open or have just closed. Further, the lighting load begins after the factories are closed. Thus the power load levels up the hollows in the lighting and traction loads, giving a fairly steady demand from five in the morning to eleven o'clock at night (see Figs. 6 and 7). The nocturnal interval between these hours is the only blank in the round; and even that the enterprising engineer will seek to fill up by tacking on a chemical works, which requires power continuously night and day, or a newspaper

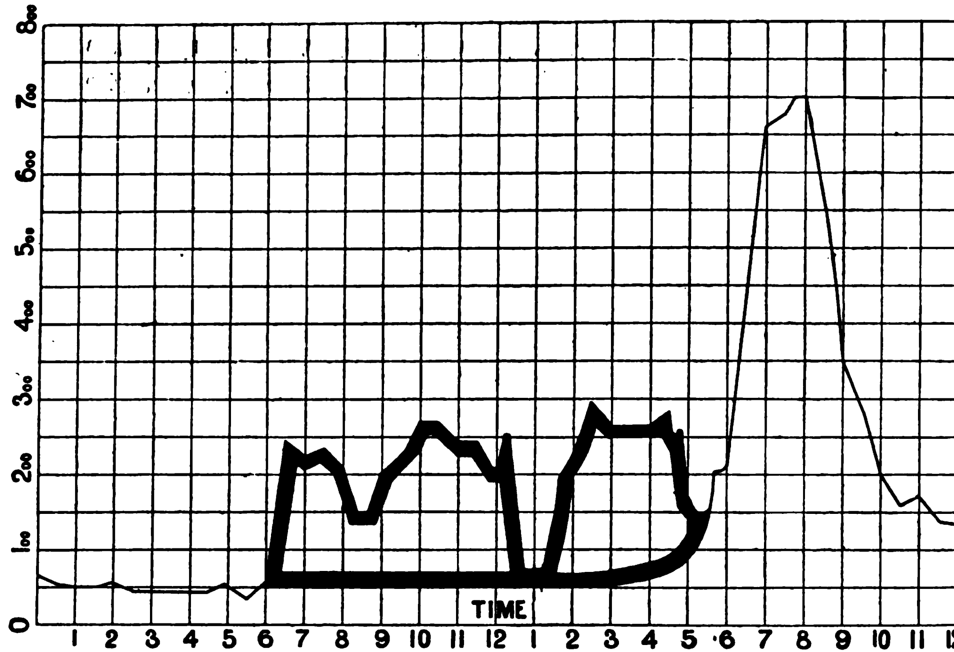


FIG. 6.—Showing how the demand for electricity for motive purposes (represented by a thick black line) fills up the low portion of the curve representing the course of the daily demand for lighting purposes, thus tending to equalize the output of the generating station. (From a paper read by Councillor Panton, of Bolton, at the Convention of the Incorporated Municipal Electrical Association, 1903.)

office or two, which demand their maximum power when all decent people are sound asleep in bed.

By thus mixing his demands as much as possible, the engineer is able to get along with a station which is of smaller power than the total of all the demands. By the same process he gets

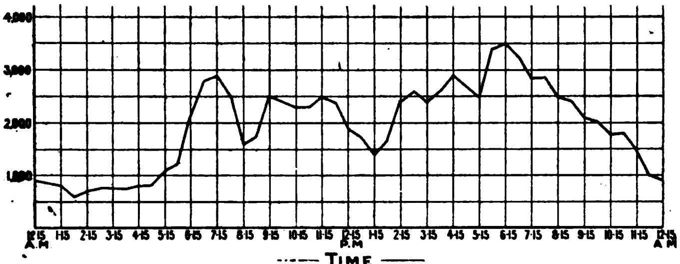


FIG. 7.—A 'day load curve' at the Newcastle-upon-Tyne Electric Supply Company's power station, showing the more uniform and continuous demand obtained where a power load is added to those for lighting and traction. (*Reproduced by courtesy of* THE ELECTRICAL TIMES.)

a high 'load factor,' a term which expresses the relation between the actual output of a station and its maximum output running continuously. The higher the load factor, the nearer the generating station comes to giving its 'full pennyworth' of value, and therefore the more economical and productive of revenue it becomes. Company promoters are supposed to have no principles, but

the engineers of the electrical companies they promote have at least this guiding principle: get as many different demands on the generating station as is possible, and never rest content until your load factor is as near 100 per cent. as human limitations will allow.

We need not press this matter further than to point out that the economies resulting from such a combination of demands are so real that each class of customer gets his electricity cheaper than if he had a generating station to himself. In practice this means that a tramway will buy its power cheaper from a combined power traction and lighting station than it could generate it by itself. We have, of course, to remember that by buying its power it saves the cost of erecting a separate generating station, which is a very heavy item indeed. Similarly with the manufacturer who is a wholesale purchaser of power for industrial, not traction, purposes. He can very often buy electric power from a company or a municipality at a price which will work out at less than what it would cost him if he put down boiler, engine, and dynamo to generate power in his own works. The following comparison between the cost for a year of steam driving and electric driving (where current is purchased, not generated)

is given by Mr. Chatwood as an actual and typical case:

Steam Driving.	£	s.	d.	Electric Driving.	£	s.	d.
Wages	72	16	0	10 per cent. on motor, etc. ...	18	5	0
Coal	213	7	6	Cleaning	1	10	0
Water	10	6	0	Brushes	1	16	0
Ash-removal ...	6	0	0	Current	164	16	2
Oil	15	0	0				
Repairs	61	0	0				
	£378	9	6		£186	7	2

The manufacturer has the additional advantages of saving of space and convenience, since, if he become a customer of an electric-power company, he simply taps the electric main as he taps the water or gas main. In time to come it may be as rare for a manufacturer to erect his own power-producing plant as it is now for him to construct his own waterworks and gasworks. Power will be bought and sold like any other commodity.

But to be bought and sold cheaply it must be produced on the only lines by which things can be produced cheaply—that is to say, wholesale. Just as a large steam factory is a more economical producer than a small one, and just as a big store is able to undersell a little street-corner shop, so a large electric generating station will produce electricity more cheaply than a small one. The

economy of wholesale production over retail is so well established and so elementary a principle that there is no need to pause to prove it; but one has to note that in the case of electric generation the mere economy of producing on a large scale is increased by the economy, already explained, of producing it for a number of varied demands. The electrical engineer was not slow in recognising that for him progress meant the production of electricity on a very large scale for a large variety of demands—lighting, tramway, railway, and canal traction, working machinery in factories, mills, shipyards, and supplying electricity for chemical works. Neither was he slow to see that, if he would attain his ideal, he must do things on a bigger scale than a single borough would allow; he must cover a dozen, a score, a hundred districts at once; he must deal with counties, not with parishes.

A large city, with a combined traction, lighting, and power demand, brings him near his object; but he now looks even beyond the limits of single cities, seeking to make them units in a still more comprehensive scheme. No one can safely say what is the 'economic limit' of an electric generating station; no one can assert that at such and such a point the size of the station will make it so cumbrous that the economies of whole-

sale generation for a host of different demands will be annulled. Other things being equal, the rule of 'the bigger the cheaper' seems to hold up to the limits of the largest power station we are likely to see for some time to come.

On the strength of these principles, electrical engineers have, with the assistance of the necessary capitalists, organized 'power schemes' for practically every populous industrial area in Great Britain. It is through the agency of these power schemes that the social revolution sketched in the preceding chapter will be brought about; but although these schemes offer cheap power to manufacturers fighting against keen competition, and although they offer the hope of many beneficial changes in the conditions of life, they have not met with great encouragement in high places. Like electric-lighting and electric-traction schemes before them, they have had to fight their way through wilful obstruction and various kinds of vexatious opposition. To some extent the struggle has been beneficial, since a hard fight eliminates all but the fittest to survive. But if anyone wonders why cheap electric power is not common to-day in England, let him read the adventurous history of the Power Bills.

CHAPTER XI

ELECTRIC-POWER DISTRIBUTION SCHEMES

IT was in 1898 that the first of the big electric-power distribution schemes made its appearance in Parliament. As behoved a pioneer undertaking, it was over-ambitious, and it trod on the toes of too many vested interests. It proposed to erect a central electric-power station at Worksop, in the Midlands, and to supply from it an area of about 2,000 square miles, including portions of the counties of Derby, Nottingham, Lincoln, and the West Riding of York. Power was to be distributed to authorized undertakers (companies or corporations holding electric-lighting Provisional Orders for single districts) and also to individual consumers.

At the same time three of the London electric-lighting companies brought in Bills to allow them to build stations outside their authorized areas of

supply, and to lay cables therefrom into these areas. This breaking of parochial bounds was not allowed for under the Electric Lighting Acts, where each district was electrically isolated from its neighbours; and Parliament, scenting a novel development in electricity supply, tied all the Bills in a bundle with red tape, and sent them to a Joint Committee of the Lords and Commons for consideration. The Committee made a lengthy report, the keynote of which was sounded in the following paragraph:

> 'Where sufficient public advantage is shown, powers may be given for the supply of electrical energy over an area including districts of numerous local authorities and involving plant of exceptional dimensions and high voltage.'

This was the first official recognition of the principle of generating and distributing electric power on the grand scale. It did not, however, avail to get the first Power Bill accepted by Parliament. The General Power Distributing Company—as the promoters called themselves—proposed to supply consumers of power in districts where local authorities were already supplying electricity; and they proposed this independently of the consent of the local authorities concerned. Naturally enough, the local authorities objected to this poaching on their preserves, and,

with the aid of their Incorporated Municipal Association, they organized Parliamentary opinion so successfully that the Bill was thrown out on its reappearance in the 1899 Session.

This failure taught the promoters of Power Bills that discretion is the better part of enterprise where powerful vested interests are concerned. Four power schemes, more limited in their range and more modest in their intrusion on the monopoly of the local authorities, passed the Parliamentary ordeal successfully in the 1900 Session, not without, however, having to meet considerable opposition. A kind of compromise with the local authorities was arranged. Large towns where a municipal supply of electricity was already given were left out of the power scheme, forming independent islands in an ocean of cheap power; in other cases (of smaller towns) the company was allowed to come in and supply large power consumers (factories, etc.) with the consent of the local authority, or without that consent if the Board of Trade decided that it was unreasonably withheld. The practical effect of this arrangement is that, if a manufacturer in a town of the latter class wants a supply of power which the local municipal station will not or cannot give him on the desired conditions, the power company may appeal to the Board of Trade to

allow it to come in and undertake the supply. These matters, and many others relating to the conditions under which wholesale electric-power supply has to be carried on, will be best understood by a short description of the various electric-power schemes now on foot. For convenience, we shall take them in chronological order, beginning with the four schemes of 1900.

The South Wales Electrical Power Distribution Company, which holds' powers of wholesale electricity supply over practically the whole of the coal and ironstone area of South Wales (over 1,000 square miles), was the outcome of a combined effort on the part of several important iron-working firms (including Guest, Keen, and Nettlefolds) and the owners of collieries, chemical works, and foundries, to obtain an ample supply of cheap power. Instead of each of these power users putting down a little power-producing plant at his colliery or works, they combined to promote a scheme for the economical supply of electric power 'in bulk,' as the phrase goes. At present the cost of power in the coal-mines works out at £15 per horse-power per annum, while the maximum price which the power company formed at the instance of the manufacturers and colliery-owners is allowed by its Act to charge is £10. In actual practice the price should not be greater

than £4 per annum. Good wine needs no bush, and these figures need no comment.

The company is free to supply all power consumers in areas where a Provisional Order for electricity supply is not in existence; the conditions mentioned above apply to cases where such Provisional Orders are already in force. This supply of power for industrial purposes is the main object of the undertaking, and to further it the company is arranging for the supply of electric motors on hire or on the hire-purchase system, so that manufacturers may obtain cheap power without the capital outlay which is in many cases a bar to the substitution of electric for steam power. In addition to this direct supply of power to manufacturers, the company has also been negotiating with local authorities to supply them in bulk with electricity, which the local authorities will in turn distribute to consumers for lighting, traction, or power purposes. In this way the central station of the local electricity-supply scheme becomes a sub-station of a large electric-power scheme. It is claimed that, by thus becoming a customer of a big wholesale supply company, the local authority obtains its electricity cheaper than it can generate it by erecting a separate small station of its own. The arrangement leaves the local authority with full

control of the work of distribution in its area, giving it the same autonomy as if it had an entirely independent undertaking. Here we see one way of reconciling hereditary enemies; the hatchet is buried in obedience to the policy of mutual advantage.

Four stations are to be erected—at Pontypridd, Bridgend, Cwm Brau, and Neath. Supply was begun from the Bridgend station in April, 1903; the other three stations were completed later. Power is supplied to manufacturers at 1⅜d. to 1d. per unit, according to quantity.

The nature of a power scheme which undertakes both the direct supply to power users and the supply to local authorities holding Provisional Orders and other 'authorized distributors' is roughly illustrated by the following diagram (Fig. 8). The figures given as representing the cost of the electricity at the various points must be taken as only approximate, as conditions vary so much in different localities. The general relations, however, are as exact as possible, and the actual figures are more liable to reduction than to increase. For simplicity, only one transmission main is shown, but in reality several of these would radiate, like the spokes of a wheel, from the power station.

We have already referred to the laying of the

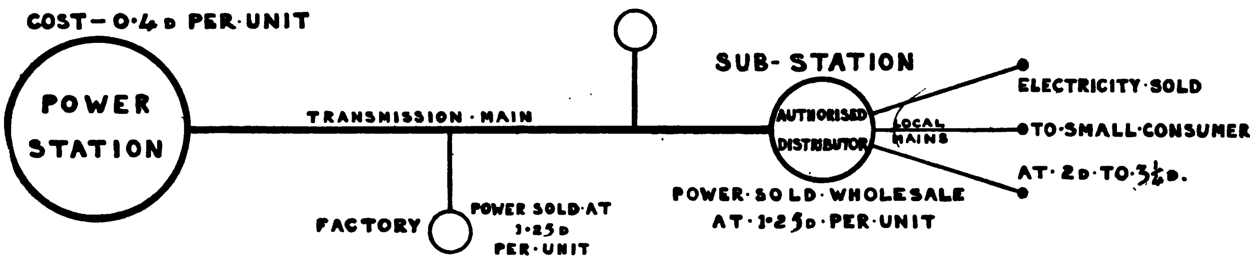


FIG. 8.—Diagram showing the general financial plan of an electrical power distribution undertaking. Factories and 'authorized distributors' are supplied at the low price of about 1·25d. per unit, and retail consumers of electric light, etc., at about 2d. to 3½d. per unit.

foundation-stone of the South Wales scheme at Pontypridd in May, 1902: it is interesting to note that already the demand for power is so great as almost to embarrass the engineers. This is a common feature among other power schemes. The difficulty is, not to find customers for cheap electric power, but to erect the plant and lay the mains fast enough to satisfy them all. Unfortunately, the work cannot be done in a day or in a year. Even a small electric-lighting station may take a couple of years to get under way, and, although four power schemes were authorized in 1900, these pioneers are only now coming into their own. As regards electric power, much more than as regards electric lighting and electric traction, one has to speak more as a prophet than as a chronicler.

The Lancashire electric-power scheme differs in character from the South Wales scheme to the extent that powers to supply direct to individual consumers of power were not asked for. All that the company wanted was permission to supply in bulk to authorized distributors or authorized users, the latter term including tramways, railways, or canals empowered by Parliament to utilize electric power. Therefore, before the company can work up a demand, it has to make friends with local authorities or companies holding Provisional Orders

or prepared to apply for them. The holders of Provisional Orders play the part of middleman between the wholesale company and the retail consumer; the power company earns its profit by supplying cheaply in bulk to a company or a corporation, which earns *its* profit in local distribution of the electricity which it buys in bulk.

Roughly described, the Lancashire scheme covers the whole of the country south of the Ribble, an area of about 1,000 square miles. Manchester, Salford, Liverpool, Bootle, Stockport, and part of Bolton, are out of the scheme altogether, having opposed the Bill strongly. The busy industrial character of the district promises an almost unlimited demand for power, to which will be added the demand for lighting and traction purposes. Since obtaining its powers, the energies of the company have been bent upon negotiations with various local authorities for the supply of electricity in bulk. These were so far successful that in the autumn of 1903 work was begun on a power station at Radcliffe, and negotiations with several local authorities were then completed or in an advanced stage. Supply is expected to commence before 1905. The prices actually offered to the small urban and rural districts are 20 per cent. below the maximum rates fixed for the company by the Board of

Trade. They run as follows: 1·87d. per unit for a supply averaging 300 hours per quarter; 1·60d. when the average is 400 hours; 1·44d. for 500 hours; and 1·33d. for 600 hours. In Liverpool, where there is a large tramway load, and where the magnitude of the undertaking greatly helps the cheapness of production, the total costs per unit are 0·92d. according to the latest figures available. They were 1·33d. in 1900. Therefore, it is clear that the prices quoted by the company for small towns are comparatively very favourable. Such towns belong to the class of districts where the costs per unit for an isolated local station are commonly as high as 3d.

The two remaining power schemes of 1900—the North Metropolitan and the County of Durham schemes—are a slight variation on the Lancashire and South Wales schemes, although the fundamental theme of power remains the same. Both schemes were promoted in connection with the British Electric Traction Company, with the intention of obtaining a cheap supply of power for tramways which the traction company had in view in the two districts. Electric-lighting and electric-power supply are to be combined with the supply for traction purposes to secure the full economy of wholesale supply for a variety of purposes.

The County of Durham scheme covers an area of 250 square miles between the Wear and the Tyne—a district where cheap coal has helped to give birth to numerous foundries, iron and steel works, engineering and ship-repairing works, mills, chemical works, docks, quarries, tinplate and copperplate works, brick works, lime works, and so on. For this area, the County of Durham Electric Power Supply Company obtained powers similar to those possessed by the Lancashire Electric Power Company—that is to say, powers of supply in bulk to authorized distributors and users. Associated with this Supply Company is the County of Durham Electric Power Distribution Company, Limited, whose business it is to get electric-lighting Provisional Orders, and play the part of wholesale customer to the Supply Company. This seems a roundabout arrangement, but it is rendered necessary by the nature of the law, which gives the company powers of bulk supply to authorized distributors and users, but not a roving commission to take out Provisional Orders and become its own customer and distributor. The arrangement is less involved in practice than it seems in theory, since the Supply Company and the Distributing Company are under the same control, and work as one. But the duplication often confuses people, who do not

understand why there should be two door-plates on the one house.

The Durham scheme has already made a start with a power station at Gateshead, which generates current for general lighting and for the electric tramways worked by the British Electric Traction Company; it also is meeting an important and increasing demand for industrial power—a demand which quite overshadows the demand for lighting purposes. This is an indication of what is likely to happen in most cases. Electric lighting, though first in point of time, is taking a position very much third in point of importance.

The associated Distribution Company holds Provisional Orders for Jarrow, Durham, South Shields rural and other districts, where supply will eventually be taken from the Supply Company's power stations.

In the North Metropolitan power area much the same sort of business is on foot. The British Electric Traction Company holds the lease of an extensive system of light railways in Middlesex and Hertford, and it will take its energy from a station erected by the North Metropolitan Electric Power Supply Company at Barnet. That company obtained powers of bulk supply over a 325 square miles area of the north of London, reaching from Willesden and Wal-

thamstow as far north as St. Albans and Ware. The North Metropolitan Electric Power Distribution Company, Limited, has secured several electric-lighting Provisional Orders; and supply for lighting purposes in Barnet from the Supply Company's power station began in September, 1900. The industrial portion of the area lies along the river Lee, and it is expected that the supply of cheap electric power will tempt the manufacturer from the crowded East End of London to the open sites available along the banks of that navigable river.

These four power schemes of 1900 are fairly typical of their class, and most of those that followed were modelled on them, with variations due to local circumstances. The Cleveland and Durham County scheme, for instance, is very similar in character to the South Wales scheme. One peculiarity of the scheme is that part of its area overlaps that of the County of Durham scheme. The area covers about 820 square miles, including the famous Cleveland iron district, and spreading further north than Durham. The two companies do not intend to quarrel over the ground they have in common. They have arranged that the Cleveland company will be the 'authorized distributor' of the Durham company within that ground. In practice, the arrangement means that

the Durham company will be able to supply the Cleveland company with electricity in bulk, which the latter will distribute to its customers. There are over 650 factories, works, and collieries in the district, so that a wide field is open for electric-power supply. Stations have been erected near Bishop Auckland and at Consett, from which electricity will be supplied in bulk to several areas under agreement with the Northern Counties Electric Supply Company, Limited, which holds the necessary Provisional Orders. Manufacturers are quoted prices ranging from 1⅜d. per unit down to 1d. per unit, according to the quantity of electricity taken per annum. Ten per cent. discount is allowed where manufacturers take current at a practically constant rate for the twenty-four hours.

The Derbyshire and Nottinghamshire scheme, again, which also appeared in 1901, was similar in principle to the South Wales scheme. Groups of manufacturers were at the back of it, and the supply of power to factories as well as to authorized distributors was its main intention. The two counties, making up a big area of some 1,500 square miles, are, with the exception of part of Derbyshire, covered by the scheme. The towns of Nottingham and Derby were excluded by request. Power will probably be supplied by this

company to a large inter-urban tramway scheme authorized in the 1903 Session. Manufacturers are being quoted on the South Wales rates—1⅜d. to 1d. per unit on a sliding scale. The company's station at Ilkeston has been at work since April, 1903, and is supplying the lighting and traction demands in that district. A second station is in course of erection at Newark.

Another successful 1901 promotion which was modelled on South Wales lines, covered about 700 square miles of the industrial portion of the Clyde valley, with Glasgow, Partick, Paisley, Govan, Port Glasgow, and Hamilton omitted. Two stations are in course of erection, and mains are being laid in anticipation of supply being commenced in July, 1904. The company has also been active in securing electric-lighting Provisional Orders. Power will probably be supplied in bulk at 1d. to 1½d. per unit, according to circumstances.

The Yorkshire electric-power scheme was authorized during the same year, and was closely similar in character. About 1,800 square miles of South Yorkshire are included in the range of the enterprise, which is thus the largest in point of area. Several of the big towns are, as usual, cut out of the scheme, but in the cases of Leeds, Bradford, and Sheffield the company is entitled

to carry its mains through the outskirts in order to reach customers in areas beyond. One interesting feature of the scheme is that power is taken to supply electricity direct to railways and canals without the consent of authorized distributors in the areas through which the lines or waterways may pass. The reason of this exceptional provision is that it would be extremely inconvenient for a single local authority to have the power of veto over the supply of electric power to one section of a canal or railway. The power company hopes to secure contracts for supplying the railways and canals with power, and it intends to use these lines of communication as routes for its mains, since in that way the factories, naturally built close to them, may be most readily reached.

The Shannon scheme, which is intended for the supply of power in and around Limerick, is a water-power scheme. In Ireland coal is dearer than in most parts of England, and it is possible for electricity generated there by water power to compete in point of cost with steam power. The common opinion is that water power 'costs nothing,' but, as a matter of fact, it may very well be dearer than steam power produced from coal. It involves elaborate dams, expensive conduits and pipes, which run up the capital cost of the installation to a high figure. Further,

there is usually someone who owns the water which is being used, and who demands a stiff rent for it. Frost and drought, moreover, are a recurrent menace, and the Shannon company has arranged to keep a steam plant in readiness as a stand-by should the supply of water give out. Added to which is the fact that available 'heads' of water are usually situated far from convenient industrial centres. In short, for convenience, reliability, and economy, the water-power installation has no points to give to the average steam-power installation, especially when the latter is placed close to a supply of cheap coal, and generates electricity on a large scale.

In the year 1902 powers were obtained for a scheme covering Leicestershire and Warwickshire similar to the Derbyshire and Nottinghamshire scheme. The county of Cornwall was the objective of another scheme of a less ambitious sort for the supply of cheap electric power to the Cornish mines and kaolin works. These schemes, with the exception of the Gloucestershire and the Kent enterprises, form the list of 1902 power Bills. The Gloucestershire company got powers of supply over the Forest of Dean collieries and the industrial portion of the Stroud valley. The Kent company takes in the whole of the county save the Isle of Thanet. The nucleus of its

power demand is to be found in and around Chatham and Rochester, where cement works and other industries are numerous. Electric lighting and traction demands are also being developed.

The Kent and Gloucester schemes are notable for being the first to obtain permission from the Board of Trade to use overhead wires for the transmission of electricity at the extra-high pressures which have to be used when long distances are to be covered. This is a tremendously important matter in the race for cheapness, although the public hears little or nothing about it. In most of the power schemes three or four sites for generating stations have been chosen, so that no point in the area is more than sixteen miles or so from a central source of power. A German or an American would consider sixteen miles to be a short distance to transmit electric power, because in his country engineers are freely allowed to use overhead wires up to almost any pressure. In England, on the other hand, underground cables, elaborately insulated and sheathed in lead, are the rule. The difference in cost is about seven to one, and the result is that with underground cables the engineer soon reaches the 'limit of economical distribution.' That is to say, if a town is more than sixteen

miles or so from a power station, it might very well be cheaper all round to erect a separate generating station in that town than to lay an underground cable from the power station, and supply the town from a distance.

Electrical engineers, as a body, appealed some time ago to the Board of Trade to allow them to use overhead wires, and thus widen the range of economical supply from a big central power station, and cheapen the cost of distributing power. The Board of Trade, when it came to look into the matter, found that the existing regulations against the use of overhead wires on poles applied to high pressures, and not to the *extra-high* pressures which the electrical engineers proposed to use in electric-power distribution. This may have been a distinction without a difference, but it gave the Board of Trade the chance of saying that they were prepared to consider all proposals for overhead transmission at extra-high pressures on their merits. Mr. G. L. Addenbrooke, the engineer to the Kent and the Gloucestershire schemes, has accordingly succeeded in obtaining sanction to transmit power at 6,000 volts on overhead wires.

Probably the permission so given will be extended to many other cases, and this cheap form of conveying electric power will become as common

in the future as it is rare at present. When that happens the power companies will be able to supply all their customers much cheaper than the prices now quoted, and they will be able to branch out rapidly into remote districts where the demand is not great enough to justify the laying of expensive underground mains. By this means the centrifugal influence of electric-power supply on the redistribution of industries will be greatly increased, and the general substitution of electric for steam power greatly hastened.

There is, of course, a certain danger to public safety attendant on carrying large currents of electricity at very high tension on overhead wires. But in open districts that danger is not intrinsically serious, and with proper safeguards it is reduced to a minimum. Experience in America and on the Continent shows that the number of fatal accidents is remarkably small, being due in nearly all cases to the negligence of workmen. In time the prejudice against overhead cables in this country should disappear, and a serious hindrance to the liberal enjoyment of cheap electric-power distribution on the large scale be removed.

The Midland Electric Corporation for Power Distribution illustrates an exceptional method of organizing power supply over a wide area. Instead

of going to Parliament for powers covering the whole area, this company applied for a large number of Provisional Orders for adjoining districts. To use a homely simile, it made a patchwork quilt instead of weaving the whole piece in one. The following are the districts for which it now holds powers; all of them are in the heart of the Black Country: Wednesbury, Amblecote, Bilston, Brierley Hill, Coseley, Darlaston, Heath Town, Lye and Wollescote, Quarry Bank, Rowley Regis, Sedgley, Short Heath, Tipton, Wednesfield, Willenhall, Kingswinford, Tettenhall, Upper Penn, Great Barr, and Bushbury.

The disadvantage of this patchwork method is that it is very slow and costly; the advantage is that it makes the company the authorized distributor throughout the entire area. Supply was begun from a station at Ocker Hill in July, 1902, for lighting, traction, and industrial purposes.

In the 1903 Session power schemes for the following districts were successfully promoted: Carmarthenshire, Shropshire, Worcestershire, and East Denbighshire; Somerset and district; Fifeshire; and an area including Clackmannan, Stirling, Dumbarton, and Linlithgow. The Somerset scheme was distinguished by the fact that Parliament included Bath and Bristol against their will;

for the first time, therefore, a power company will have the chance of entering a large town in competition with a local municipal supply. The competition is, however, to be carefully regulated to prevent rate-cutting; the towns have the same sort of conditional veto against the invasion of the company as is generally granted to small towns possessing a municipal system. In the same Session a power Bill, called the North-Western Electricity and Power-Gas Bill, was passed, covering parts of Stafford, Derby, Denbigh, and Flint. Under this scheme it is proposed to supply power-gas in addition to electricity. Power-gas is produced from coal dross, and is used for fuel purposes or for gas-engines, which may be used in the economical generation of electricity.

From the above very brief survey of electric-power schemes it is clear that most of them are still in the melting-pot. A few are in the first stages of crystallization. We have left to the last the only scheme which has got beyond these first stages, because it points out, by its achievements, the successful future which awaits its followers. In several respects the Newcastle-upon-Tyne enterprise is different from the typical power scheme, but its objective is the same, and general comparisons between what it has done and what the others are likely to do are safe enough. The

business started as a simple electricity-supply company, sharing the area of Newcastle with another company. It has gradually spread, first by acquiring Provisional Orders for neighbouring districts such as Wallsend, Walker, Willington, and Gosforth, and later (in 1902) applying for the rights of power supply over a wide area at the back of Newcastle, covering the great coalfields of Northumberland. The company—the Newcastle-upon-Tyne Electric Supply Company—started originally in 1893, and in 1901 Lord Kelvin switched on the current at the company's first big power station. A large number of works along the banks of the Tyne take electric power in large quantities from the company, and exceptionally low prices are the rule. Armstrong, Whitworth and Company, for instance, pay about 1·161d. per unit, and the North-Eastern Marine Engineering Company pays even less—1·08d. per unit. The standard rates charged by the company vary from 1½d. to 1d. per unit, with discounts; and current for traction purposes has been supplied at 1¼d. to 1d. per unit, depending again on the quantity. According to the latest available figures, the company produces electricity at the low price of 0·37d. per unit. The calculations of most power schemes presented to Parliament reckoned the cost at about 0·4d. to 0·7d. per unit, so that actual

attainment is already within the limits which were put forward as possible and profitable.

Besides the large industrial power load and the lighting demand in Newcastle and neighbouring districts, the company supplies power in bulk to the Tyneside tramways, and has contracted to perform a similar service to the electrified portion of the North-Eastern Railway. Thus it already enjoys a high diversity factor which enables it to generate economically and supply cheaply. It must be admitted, however, that the area already exploited is a very concentrated one, and therefore does not require a very heavy outlay in distributing mains. A power company which has to go further afield for so large a power, lighting, and traction demand will not fare so well, unless, of course, it uses overhead mains. Distance would then be 'no object,' and the customers of a company with a spread-out district would be supplied almost as cheaply as the customers crowded round a company's power station.

The following is a list of the principal electric-power distribution schemes, with the authorized share capital of each and dates of promotion. As a general rule, Parliament grants borrowing powers up to one-third of the share capital. In several cases power has been taken to pay interest out of capital during construction:

	£
South Wales Electrical Power Distribution Company (1900)	750,000
Lancashire Electric Power Company (1900) ...	3,000,000
County of Durham Electric Power Supply Company (1900)	500,000
North Metropolitan Electric Power Supply Company (1900)	500,000
Cleveland and Durham County Electric Power Company (1901)	1,000,000
Derbyshire and Nottinghamshire Electric Power Company (1901)	1,800,000
Clyde Valley Electrical Power Company (1901)...	900,000
Yorkshire Electric Power Company (1901) ...	2,000,000
Shannon Water and Electric Power Company (1901)	360,000
Gloucestershire Electric Power Company (1902)	250,000
Cornwall Electric Power Company (1902) ...	450,000
Leicestershire and Warwickshire Electric Power Company (1902)	750,000
Kent Electric Power Company (1902)	750,000
Midland Electric Corporation for Power Distribution	200,000
Newcastle-upon-Tyne Electric Supply Company, Limited	750,000
Carmarthenshire Electric Power Company (1903)	600,000
North-Western Electricity and Power-Gas Company (1903)	1,500,000
Shropshire and Worcestershire Electric Power Company (1903)	300,000
Somerset and District Electric Power Company (1903)	750,000
Fifeshire Electric Power Company (1903) ...	600,000
Scottish Central Electric Power Company (1903)	600,000

CHAPTER XII

ELECTRICAL ENGINEERING AS A CAREER

IN a world where economic values, like water, tend to find the same level, no one profession or career is conspicuously worse or better than another. Each has its advantages and its balancing disadvantages. If there is an apparent abundance of 'plums,' they have to be paid for with hard work and long, expensive years of probation; if good salaries are earned at an early period without a costly education, chances of improvement will be absent or rare. Hence the choice of a profession is just about as difficult as the choice of a wife; and, as a matter of fact, people drift into various careers just as they drift into matrimony, unless the French system of paternal choice is adopted in both cases.

However, the electrical industry affords a career which has a different quality from most established callings. It is in very much the same position as

the Israelites when their spies returned from the land flowing with milk and honey. If it has not altogether escaped from the bondage of autocratic powers, it has, at least, passed the Red Sea of its troubles, and come to the borders of the Promised Land. Its future bears the genuine promise of great development; in every department 'to-morrow' is a vastly more important thing than 'yesterday' or 'to-day.' No other industry, perhaps, has in greater measure this capacity for growth and progress.

Hence it happens that the electrical industry is less overstocked than most of those which attract the energies of the rising generation. It is full of opportunities for the skilled mind and competent hand; and the only compensating drawback is that as time goes on the double qualification becomes more difficult to acquire. In days gone by, all that a branch of engineering demanded by way of training was apprenticeship in the 'shop,' where the requisite practical training, and most of the theoretical training, too, were acquired as matters of routine. The development of applied science has changed all that. What is demanded now is a capable engineer with a knowledge of the properties and working of various materials, combined with a sound mathematical and scientific training. As Professor J. D. Cor-

mack said in discussing this matter before the Engineering Conference of 1903: 'The raw material is a youth of seventeen or eighteen, fresh from school, educated, perhaps, to a standard below that which might be desired or expected, and supposed to be endowed with natural aptitude for the profession and common-sense; and the finished product is a blend of scientific and technical knowledge, practical experience, and business method.'

No two engineering authorities see eye to eye on the question how this blend is to be produced. The heart of the trouble is that the double training takes a long time (involving expense), and that the two halves are not easily worked together. In the absence of any widely-accepted mode of training, we will summarize those generally in vogue, following the simple classification made by Professor Cormack in the discussion already mentioned.

Some people adhere to the old practice of workshop experience only, tempered by theoretical study in the evening. This involves a heavy strain, and means, in reality, a fourteen or fifteen hours' day. Many young engineers go through it, however, and attend classes two or three nights per week at a technical college during their apprenticeship. Occasionally—as, for instance, at

Glasgow University—there are engineering classes at eight in the morning, attended by budding engineers, who make arrangements with their employers to get off the first part of the day's work. This is perhaps the only method open to those of limited means who are ready to work particularly hard to economize time and money.

Others leave out the workshop training, and devote themselves entirely to training in an engineering or technical school. Some of these schools give a fair measure of practical training, and some even make an attempt to reproduce the exact conditions of workshop practice; but it stands to reason that a college workshop is never the same as one which is working under commercial conditions. One of the qualifications of a successful engineer is tact in dealing with men, and that, certainly, will not be acquired outside a genuine workshop. For that and other reasons most engineers do not regard the technical school, however well equipped, as a satisfactory substitute for practical experience in a factory.

The two modes of education are sometimes combined in horse-and-cart fashion. Under one arrangement the boy, after leaving school, has three years' factory experience, and then takes a college course. This method has the advantage of giving the boy a very fair chance of testing his

liking for the work before it is too late to change; it has the disadvantage that workshop life may tend to destroy habits of study that are essential in the college course. If, on the other hand, the reverse process is gone through, the student's appreciation of the information he receives is reduced by his lack of knowledge of its practical application. Professor Cormack suggests that college workshops may reduce this drawback, while the actual workshop training later gives the necessary commercial tone to the student's combined theoretical and practical education.

Variations of these two methods of education are also in vogue. The college and workshop courses may be alternated during a period of five years or so. The usual nine months' college course may alternate with three months' workshop, or six months of each year may be allotted to each section, sandwich fashion. Which of these modes should be adopted depends a great deal upon circumstances, as some employers object to have their workers coming and going; one advantage is that the change of occupation lends a certain zest to the young engineer.

These remarks apply generally to all engineering trades. It is often argued that an intending electrical engineer, in addition to following one of the above courses for electrical engineering alone,

should begin his experience with a year in a mechanical engineer's shop, since there he may best obtain an all-round knowledge of materials. For the special training of electrical engineers all the important universities and technical colleges and schools now make more or less elaborate provision, beginning in most cases with a foundation of science and general engineering. A few brief descriptions of the electrical engineering curricula in some representative institutions will help to show how the education of the electrical engineer is tackled from the more or less theoretical side.

In the University of London, where the electrical engineering department is supervised by Professor J. A. Fleming, one section of the engineering laboratories is set aside for a complete course of instruction in the scientific principles of electrical engineering. The laboratories are equipped with dynamos of various kinds and all forms of electrical measuring instruments. Lectures, experimental demonstrations, and individual laboratory work go hand in hand through a three years' course, which is intended to supplement the practical experience gained in workshops or drawing offices.*

In the City and Guilds Central Technical

* These remarks apply also to the 'James Watt' Engineering Laboratory at Glasgow University, one of the best equipped in the kingdom.

College (Exhibition Road) the course of study under Professor Ayrton has, if anything, a more practical bent. The lectures are mainly explanatory of laboratory work, which passes from practical physics to 'electrical technology.' Practically the whole range of electrical enterprise is covered, from telegraphy to the principles of dynamo construction. Each student in succession takes charge of the steam-engines, dynamos, and motors for one week; for another week of the boilers, feed-pump, and heating apparatus; he also has to devote two weeks to the supervision and maintenance of the various storage batteries, and act as switchboard attendant in connection with the lighting. A somewhat similar course of instruction is carried on under Professor Silvanus Thompson at the Finsbury branch of the same institution. The instruction at this branch is intended as a finishing technical school for those entering industrial life at a comparatively early age, or as a supplementary technical college for those who, having had some industrial experience, intend to become foremen or managers. The Finsbury branch is an intermediate college in the educational scheme of the City and Guilds of London Institute, leading up to the Central Technical College.

Provincial technical colleges are organized on much the same lines. The Glasgow and West

of Scotland Technical College has, for instance, a complete course of lecture and laboratory instruction in day and evening classes under Professor Magnus Maclean. In conjunction with the affiliated Allan Glen's School, a carefully planned course of industrial education is afforded from the age of ten or less up to the age when the student leaves college qualified for an engineering profession or trade. Many students take the evening classes after work in the shops, and the day courses may be taken sandwich fashion or otherwise according to circumstances. In the engineering section of the University of Birmingham the practical and experimental side of the training is emphasized in much the same way as obtains in University College, London. At the Yorkshire College, Leeds, which is another well-known institution where the engineering branches of education have been highly developed, the lectures on electrical theory and the design of electrical instruments and machinery are closely bound up with laboratory work, and students have opportunities of testing and repairing electrical apparatus, cables, and so on in the electrical engineering workshop. As in the Exhibition Road branch of the City and Guilds of London Institute, the students take in turn the superintending of the electric-lighting plant for a week.

From this rapid survey of a few leading technical institutions, taken almost at random, we see that the electrical engineering student may obtain therein a knowledge of electrical theory, the principles of electrical machinery design, testing, and operation, and the use of ordinary tools, together with a training in accuracy of thought and handiwork. What is wanted in addition is a knowledge of work under actual commercial conditions, of business organization, and of tact in dealing with other men who are part of that organization. That can be obtained, we repeat, only in the workshop, and to the workshop the electrical engineer (to be) must go. He may go either as an apprentice, and work his way slowly upwards, or he may go as a pupil, and be afforded, in return for premium payments, all the advantages of instruction which the works can afford, in addition to assistance in obtaining a position after his time is completed. Several of the leading electrical engineering firms take pupils on various conditions, of which the following are representative samples.

The Electric Construction Company, Limited, which is one of the oldest electrical manufacturing businesses in the country, has four pupils in each of its departments at Bushbury Works, Wolverhampton. Intending pupils must not be under seventeen years of age, and must have had

a sound general and scientific education. The premium payable is £300, in annual instalments of £100 each, and the pupils pass in rotation through the following departments: Pattern-maker's shop, foundry, heavy machine shop, fitting shop, erecting shop, winding shop, testing department, drawing office, and central power station. Wages are paid during the first year at the rate of 2s. 3d. per week of fifty-three hours, during the second year at 6s. 9d. per week, and during the third year at 11s. 3d. per week. As a general rule, pupils who have satisfactorily completed their course are appointed probationary assistant engineers at a commencing salary of £40 per annum, and enjoy preferential treatment when vacancies occur on the staff of trained electrical engineers.

The General Electric Company, Limited, which has works at Witton, near Birmingham, for the manufacture of dynamos, motors, and electrical transmission plant, and at Manchester for switch-boards, arc-lamps, electric cooking and heating apparatus, telephones, telegraph instruments, and so on, takes pupils under three groups. The first group pay a premium of 300 guineas and take a three years' course, covering all the departments at both works, with a month at the head office in London. The second group pay 200 guineas

as a premium, and take a three years' course at either of the works, including a month at the head office. In both cases wages are given after the first six months of training, at the discretion of the manager. The third group (not above seventeen years of age) do not pay any premium. Their training lasts until they attain twenty-one years of age, and they work in one only of any of the company's departments. After the first six months 3s. per week are paid in wages, rising every six months by 1s. per week. The company also gives practical training for one year, at arranged premiums, to gentlemen who have had a thorough electrical college or technical school education.

At Messrs. Johnson and Phillips' works, Old Charlton, Kent, where dynamos, motors, transformers, arc-lamps, and most other classes of electrical machinery are manufactured, pupils of sixteen years and upwards are taken on a three years' course at a premium of 300 guineas for the complete course. Pupils pass through all the departments, and are also free to learn the commercial side at the company's London office. A professor is specially engaged to give theoretical instruction concurrently with the practical course, and a technical library is available for the use of the pupils.

The Brush Electrical Engineering Company offers at its works in Loughborough, Leicestershire, a course of practical training specially adapted to enable engineers to take up appointments on the staffs of electric traction, power, and lighting undertakings with which the company is in alliance. These include the British Electric Traction Company and its associated companies, numbering over fifty. Pupils are admitted on satisfactory evidence of mental and physical qualifications, and pass through a three years' course, divided as follows:

1st year	Iron foundry	3 months.
	Brass foundry	1 month.
	Pattern shop	2 months.
	Smithy	1 month.
	Dynamo shop	3 months.
	Light machine shop or car wiring ...	2 "
2nd year	Switch shop	3 "
	Truck shop	3 "
	Winding shop	3 "
	Testing shop	3 "
3rd year	Electric Lighting and Power Company, or	12 months.
	Electric Traction Company, or ...	
	Contract work, or	
	Further workshop experience ...	

The premium for the course is 300 guineas, and wages are paid at the rate of not less than 3s. and not more than 18s. per week. During

the third year a payment of £3 per month is made to pupils retained by one of the associated companies. Facilities are afforded for evening studies and discussions, and a technical library is open to the pupils.

At Crompton and Company's Chelmsford works (one of the oldest established electrical manufacturing firms) pupils usually enter the works about the age of twenty, with some technical training or a University degree. During the winter months evening lectures are given by the heads of departments and others four times a week on subjects connected with the actual work in the shops. The course occupies three years, and enables the pupil to go through every department. The premium is, as usual, £300. During the last twenty-five years 190 pupils have passed through these works, and the company has records of 110 of them who now occupy positions of importance as electrical engineers.

The British Westinghouse Electric and Manufacturing Company, which recently opened enormous works at Trafford Park, Manchester, has, on the other hand, an elaborate but well-arranged system of apprenticeship. A regular form of apprenticeship agreement is entered into in all cases. Two courses, covering thirty-six months and forty-eight months respectively, are arranged.

Applicants for the first must be not less than eighteen years of age and have had two or three years' training at a recognised technical college. Applicants for the second must be not less than sixteen years of age and must have had an ordinary school education. There is also a series of what are called 'trades' courses,' in which one particular department is selected, open to boys of sixteen years or over who have passed the fifth standard of the public schools or the equivalent. The wages for the first course range from 1½d. to 4d. per hour, for the second course from 2¼d. to 4d., and for the trades' course from 1½d. to 3d. Apprentices who show special ability and industry are promoted to positions in the shops, engineering, testing, drawing, commercial, and other departments. There is no premium.

A word may be said here regarding an institution which endeavours to combine theoretical, technical, and practical business instruction in electrical engineering. The Electrical Standardizing, Testing, and Training Institution, familiarly known as 'Faraday House,' was organized by a group of electrical engineers for the special purpose of training competent all-round engineers. The full course of instruction occupies three years. The first is spent at Faraday House (in London), for instruction in the use of tools and electrical

instruments and apparatus and in general workshop practice. The second is spent at the works of firms engaged in the manufacture of steam-engines and boilers. In the third the student passes to an electrical engineering works, and acquires experience in the construction and use of electrical plant. The student then takes an appointment in an electrical works or generating station. Over seventy companies and engineers are affiliated with the institution, which claims that more than 80 per cent. of its students have secured appointments immediately at the close of their apprenticeship. The fees amount to £105 per annum.

Although the full training of an electrical engineer demands a considerable outlay of time and energy, and, in many cases, of money, one cannot say that the immediate prospects of remuneration open to him after the completion of his instruction are tremendously bright. They are no worse, perhaps, than those open to the young doctor, lawyer, or minister, but they are not conspicuously better. The following table, for instance, represents the general scale of wages in an English electrical manufacturing firm. Individual merit may, and often does, vary the actual amount paid; but the figures, which have been supplied by the works director of one of the

largest firms in the country, indicate the general scale of remuneration:

Shop foremen and assistants and test department ...	£2 10s. to £4 per week.
Shop inspectors	£2 to £3 per week.
Estimating department ...	£3 to £7 per week.
Clerical staff varies up to ...	£5 per week.
Draughtsmen	£1 10s. to £3 10s.
Assistant staff engineers and electricians	£3 to £5 per week.
Chief draughtsmen	£300 per annum upwards.
Heads of departments... ...	£400 " "

If the new-fledged engineer of twenty to twenty-five years of age gets an appointment on the staff of an electric lighting, traction, or power station as assistant engineer or mains superintendent, he may receive about £12 or £15 per month. Large stations have three or four 'shift engineers,' who are paid about that rate. The engineer in charge of a small station enjoys a salary of about £250; as the size of the undertaking increases his responsibilities are enlarged, and his salary may rise as high as £1,000 or £1,600 per annum. In the latter case the shift engineers might get as much as £400 per annum. Salaries vary tremendously, however, according to the liberality of municipalities and the means of companies.

In tramway schemes there is a chance of promotion also in the direction of traffic super-

intendent or traffic manager. Birmingham recently offered £1,500 per annum for a traffic manager, and it invited first the Leeds manager, who was receiving £900, and then the London County Council tramway manager, who was receiving £1,000, per annum. In smaller systems the rate of remuneration is, of course, less, but for a man of good business training and organizing ability electric tramway management offers the same sort of scope as railway management.

It may be noted in passing that there is a growing tendency to employ girls in the lighter branches of electrical engineering. In the manufacture of electric incandescent lamps girls are almost wholly employed, and at the Robertson Electric Lamp Works they earn from 8s. to £3 10s. per week. At Crompton and Company's works, near Chelmsford, several girls are employed in the instrument-making department.

In the electrical industry, as in kindred departments of engineering, it is the consulting engineer who gathers the plums. There are consulting engineers of all sorts; some have years of experience and success to recommend them, and others have only impudence and a large brass plate. Both types often enjoy a wide 'connection,' which they have developed either by merit or by push. In all cases the fees are on a liberal scale. Com-

mission is paid to them at the rate of 5, or sometimes 10, per cent. of the capital expended on the undertaking they design and supervise, so that an occasional power station costing £100,000 means a very substantial income. In addition, the consulting engineer is often called upon by local authorities to 'report' on the prospects of electric lighting or electric traction; the fees for this work (which is often very simple to a man with a little experience) vary from £50 to £500 or so. It is no wonder, therefore, that Victoria Street is as full of consulting engineers as Harley Street is of doctors.

CHAPTER XIII

THE FUTURE OF THE ELECTRICAL INDUSTRY

A WORD may be said in conclusion regarding the future of the industry whose main outlines have been sketched in preceding chapters. No adequate idea of that future could be conveyed without the use of a large canvas and a big prophetic brush; and it is necessary to limit our forecast to a simple indication of the lines of advance.

Taking electric lighting again first, there is every reason to believe that its steady progress will be hastened by a cheapening of supply. Not only will the extension of electric power distribution on the large scale enable electricity for lighting purposes to be obtained cheaper, but further economies in the conversion of electrical energy into light will also be effected. Dr. J. W. Swan states that the glow lamp has by no means reached the limit of practical efficiency. Recently,

moreover, the Nernst lamp has been brought to a reliable commercial form. The light-giving part of that lamp consists of a small rod of certain 'rare earths,' which becomes brilliantly incandescent under the action of an electric current. It is claimed that this lamp gives increased illumination, with a reduction in consumption of current. The Osmium incandescent lamp also offers an alternative to the carbon filament, but so far the metal has not been made suitable for the 100 or 200 volts pressure of ordinary lighting circuits.

The Hewitt mercury vapour lamp is a radical departure from these incandescent forms. It consists of a glass tube filled with mercury vapour, which, when traversed by a current, glows brightly. Very little current is used, and the only serious drawback to this most economical form of electric light is the entire absence of red rays. Complexions become livid under its beams, and colour values are destroyed. No doubt a way will be found of obviating that æsthetic drawback. The lamp is being developed from the laboratory to the commercial stage by the Westinghouse Company.

By effecting economies in prime cost and in consumption of current, the price of electric light should be brought well below the price of gas. The result should then be a great stimulus to the

extension of electric lighting. However that may be, there is no doubt that electricity will supply the light of the future in some form or another.

The future of electric tramways is, if anything, more definite. The systems which exist must be looked upon merely as nuclei of still greater systems, which will extend until there is a continuous web of tramways over the whole of our populous areas, and extending by tramroads or auto-trolleys into rural districts. In this way a great secondary system of transit will be built up. Coincident with this process there will proceed the reorganization of our primary system of transit; in other words, the conversion to electric traction of our steam railways. The latter change may be far in the future, but already there is a sort of settled faith that in this department of enterprise, as in so many others, steam must give way to electricity. On our canals, likewise, horse or steam haulage will be abandoned for the electric tractor.

As regards the use of electric power in our industries, we have already discussed the revolution which is pending. Here the victory is no less certain. It is simply a matter of time. In the future a supply of cheap electric power will be available wherever it is wanted, and the direct use of steam power will become as rare as water-mills are now. This branch of

electrical enterprise will, in common with electric lighting, be greatly encouraged if the Board of Trade succeeds with the Electric Lighting Bill which it has drafted. That Bill repeals the 'veto' of the local authorities, and enables power distribution companies to adopt the simple procedure of Provisional Order when applying for powers.

Many other electrical developments might be treated in the same way. Electric automobiles, for instance, are likely to undergo great improvement and progress in connection mainly with urban street traffic. Electro-chemistry and electro-metallurgy are, moreover, two branches of the electrical industry as yet in the early stages of evolution. The whole future might well be summed up in the statement that electricity will play a dominant part in almost every department of external human existence. The statement is redeemed from extravagance by the fact that electricity is the most versatile and controllable form of energy yet discovered by man. The mere catalogue of its protean accomplishments is bewildering. It may be used for lighting, for heating, for all sorts of motive purposes, as a chemical agent, for the transmission of power or the transmission of signals, as a curative force in various diseases; and in each phase of its activity it

represents an advance in the conquest of Nature and opens up fresh opportunities of bending the elemental forces to the improvement of the conditions of life. In the service of man it plays many parts, and plays them all well.

Turning to the purely commercial side of the picture, we find that electricity has already afforded an ample outlet for the profitable employment of capital. Hampered though it has been in this country by restrictive legislation and the entanglements of politico-economic disputes, it has already reached an established position in the industrial world; and its early achievements under unusual difficulties are the best guarantee of rapid advance now that these difficulties are showing signs of gradual dissolution. One cannot deny, however, that at present the law relating to electrical matters is chaotic and illiberal, and that the demands for reform, which come insistently from all quarters of the electrical world, will have to be met by the Government before the electrical industry can show its full strength. With that reservation, the outlook for the industry is one of unusual hopefulness. We may be, as Mr. J. S. Forbes has said we are, a little mad on electricity, but there is method in our madness.

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